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Properties and Housing

SDI & SIM 2013 *International Conference*

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FIRST PRIVATE UNIVERSITY

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All papers have been reviewed by the international scientific committee!

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November, 2013

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GENERAL INTRODUCTION

The "International Conference on Spatial Data Infrastructures & Spatial Information Management 2013" was held during November 13-16, in FON University, Skopje. The Annual FIG Commission 3 Workshop and Meeting was joined by 'FIG Task Force on Property and Housing' (FIG-TF-PH) and 'South-East European Research Institute on Geo-Sciences' (Geo-SEE Institute) to form the first International Conference on Spatial Data Infrastructures (SDIs) and Spatial Information Management (SIM).

The main focus of the conference is the development and use of spatial data through SDI and SIM Systems, together with relevant aspects, such as technology, criteria and standards for organizing and sharing spatial data. The realization of the European INSPIRE directive in the countries of South East Europe is an important part of the conference.

The conference brought together stakeholders interested in the development and use of spatial data, focusing on the region of South-East Europe. Participants from all over the world contributed with their research and experience. Scientist, researchers, industry and data owners from public or private sector contribute to increased understanding and awareness of spatial data in the region, and to the identification of new ways of their implementation and use.

Participation of professionals from all over the world, especially from European countries in the conference, shared their experiences in developing and using spatial data in their countries. Through scientific and practical solutions presented by the participants (scientific institutions-researchers, governmental and private sector organizations), and fruitful discussions and papers, methodologies and ways are put forward, which helped finding alternatives and solutions for developing spatial data in the region, and internationally, for special purposes and applications.

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A research on the principles of bioclimatic street design and the application of a bioclimatic regeneration project in the Municipality of Kifisia.

Efthimios BAKOGIANNIS, Maria SITI, Angelos SIOLAS, Greece

Key words: bioclimatic design, environmental planning, urban heat island effect (UHI)

SDI, Environmental Planning

SUMMARY

Urban streets and public spaces represent the communicative and social background of a city. Urban space nowadays has been overcrowded by cars which has led to well-known impacts in terms of reduced pedestrian security, has increased air and noise pollution as well as delays for other means of transportation. Continued urbanization increases urban activities, which, according to the UN (UN, 2010), constitute 80% of anthropogenic CO_2 emissions produced globally, meaning that cities define the ecological phenomenon of climate change in the 21st century. The burden of the heat balance in the urban environment has resulted in the increase of temperatures in urban centres compared to the corresponding values in the neighbouring rural areas. This phenomenon, known as the urban heat island effect (UHI), is caused mainly by urban planning characteristics, lack of green spaces as well as the thermal and physical attributes of construction materials used in buildings and city surfaces in general. The conventional materials used in urban spaces have been proven non-reflective, increasing surface temperature which together with the phenomenal reduce of green spaces in Greece has led to an extensive downgrade of the street environment. According to all these, contemporary urban planning schemes should encounter the microclimate as an important element in designing outdoor spaces and materials have to play an important role in making streets and public spaces cooler.

Considering the above, this paper examines the methodology to be followed for examining, understanding and applying the parameters of thermal comfort in order to make urban streets cooler and friendlier to all users. This methodology consists of four consecutive steps; firstly the analytic recording of the various climatic parameters (temperature, relative humidity, wind speed and direction) and particulate air pollution according to traffic congestion, secondly the selection of most traffic congested and polluted streets in order to be modified, thirdly the defining of the most absorbing surfaces in the selected zones in order to be regarded as the first priority and finally the determination of intervention procedure depending on the heat strain as identified by the measurements of the first step.

This paper also presents the implementation benefits of a pilot application in a street in the area of Nea Erithrea in North Attica. According to the methodology, the study group measured the surface temperatures of the various materials, compared the temperatures of shaded and unshaded materials, while also analyzed the concentration of the particulate pollution etc. After thorough analysis, the intervention procedure was formulated and the regeneration project included a whole new approach in the design of the street. Traffic calming techniques were applied while special attention was paid to materials. Conventional

paving materials are being replaced with photocatalytic road surfacing and others (i.e. granite) that apply to the High solar reflective Cool Technology. After the completion of the roadworks, measurements are repeated regarding the exact same factors as previous to test the success of the whole endeavor, showing a 2-3°C reduction of the surface temperature which causes a 10-15% reduction of the energy for cooling the neighboring buildings and an increase of about 20-25% of the level of thermal comfort.
The research results and outcomes of the implementation project indicate that the development and usage of such a land tool, that identifies places of intervention and guides through the completion of the work, is particularly innovative and useful in a country with almost 9 months of insolation. The bioclimatic street design methodology promotes the actual sustainable development of urban spaces and introduces a different mentality in street design.

A research on the principles of bioclimatic street design and the application of a bioclimatic regeneration project in the Municipality of Kifisia.

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1. INTRODUCTION

The dynamic emergence of cars in the street environment established somewhere in the 20th century, a freedom of mobility, which satisfied the needs of travelling, leisure and social status upgrade. However this 'new freedom' pushed city limits in the rural space, expanded urban fabric, forced densities to be decreased and loosened urban centers, in the name of a healthier urban environment. Contemporary planning attempts to redefine the importance of urban density and enhance city identity, as story showed that increased densities are not incompatible to hygiene and quality of urban centres, instead they restrain aimless travels, enhance urban mobility, add on spatial and socio- economic cohesion et cetera. The private automobile domination generated numerous issues of safety, air and noise pollution, delays and most importantly altered dramatically the aesthetics and construction attributes of road spaces and consequently public spaces. Traditionally streets were made from various materials and colours, constituting public space, revealing at the time social characteristics, relationships, aesthetics and correlations between natural and structural environment. Today street network is completely allocated to cars; mostly covered with asphalt, burying specificities, allowing only horizontal signs of traffic control and regulations. Nevertheless, apart from the aesthetic and social part of the issue, extended car presence increases pollution and the usual paving materials impact greatly on thermal comfort of the urban environment. The main issues that current street/ road design is expected to tackle are; ventilation and cooling of the urban fabric, discharge of pollutants and consumption of natural resources, air and noise pollution, temperature increase (urban heat island effect -UHI) (Greek Open University,2001). The selection of materials used in contemporary urban regeneration schemes should deal with the above and be in accordance to the neighbouring buildings and public spaces. Regarding the difficulty of abrupt changes and holistic approaches to intervention processes in planning, the need of a new strategic land tool, which will identify potential places and suggest bioclimatic street regeneration projects, is apparent in order to improve urban microclimate and enhance the street environment.

2. AIMS AND OBJECTIVES

The key subjects analyzed in this project are; promotion of urban public space, overall exploration of the aesthetic identity of the street, appropriate selection of construction materials and proper identification of environmentally degraded areas.

The paper aims to be a critical alternative implementation of climate action planning in the street level. It attempts to cover the theoretical background of bioclimatic street design describing key parameters such as microclimate, urban green, materials and design tools. The proposed 4- step methodology encourages the selection of particularly depressed urban streets to be redesigned according to bioclimatic criteria, by presenting the procedure followed in the case of the north Athenian suburb of New Erithrea- an exemplar case of intervention as the analysis of previous situation and post- implementation characteristics largely confirmed the key aim of intervention. The analysis of the case presents data analysis regarding environmental characteristics before and after the implementation, adding on the debate pro bioclimatic design of urban spaces and streets.

Conclusions are drawn in the direction of overall sustainable redevelopment- not limited to architectural perspectives and construction materials- but rather researching balanced solutions concerning equal respect for the citizen and the urban environment.

3. THERMAL COMFORT AND BIOCLIMATIC DESIGN OF SPACES

3.1 THE ROLE OF MICROCLIMATE IN URBAN SPACE- THERMAL COMFORT

Considering microclimate in the design of outdoor spaces aims at creating comfortable environmental conditions for people. The burden on urban heat balance has resulted to an extended increase of temperatures in cities compared to the corresponding values in neighbouring rural areas. The aforementioned Urban Heat Island effect (UHI) is observed due to lack of green spaces, deficient urban planning characteristics as well as thermal and physical properties of construction materials commonly used in city surfaces.

Thermal comfort is the condition in which the human being feels pleased with its thermal environment and do not pursue any changes or as defined in the ISO 7730 standard: "*That condition of mind which expresses satisfaction with the thermal environment*". Research and understanding of the parameters that constitute thermal comfort in outdoor spaces, are basic requirements for the microclimatic oriented urban planning, including the planning of green areas. Level, intensity and efficiency of activities regarding thermal comfort accomplishment depends on comfort or discomfort level experienced by humans when exposed to specific climatic conditions. Three physical parameters should be taken into account in order to assess thermal environment; temperature, humidity and air velocity.

Presence of objects (i.e. terrain, structures) in the environment affects the wind in various ways relative to their position and orientation, either with speed increase/ reduction or change of direction. The key features of buildings regarding their effect on thermal comfort are: size, position, orientation, porosity and their proximity with one another, while the diurnal variation of wind speed depends on season, weather conditions, surface conditions (sea or land) and height.

Particulate Matters (PM) are produced either by combustion processes or through the heating of car and domestic engines or through natural sources such as dust. Traffic volume as well as the type and quality of fuels used determines predominantly the concentration of particles in an area. Small diameter particles are considered to be easily respirable, causing major health problems.

Vegetation also affects the microclimate in numerous ways; improves natural ventilation, provides shade and decreases summer temperature, ensures protection in cold winter temperatures, reduces air and noise pollution, holds and absorbs rainwater and thus prevents flooding, protects flora and fauna et cetera. In general, green spaces provide natural shading capable of reducing surface temperature of different materials up to 2^{o} C (Heisler, 1990) and current environmental researchers stress the need for many small pocket parks rather than large scale parks, in order to achieve better distribution of environmental relief in urban centers.

According to all the above parameters of microclimate, bioclimatic design of spaces should tackle (Greek Open University, 2001);

- Densities and urban fabric formulation
- Urban canyon effect (geometric combination of horizontal and vertical surfaces in the streetscape)
- Surface properties (reflectivity, heat capacity, porosity)
- Lack of proper provision of outdoor spaces
- Lack of green and water surfaces

3.2 BIOCLIMATIC STREET: NOTIONS AND DEFINITIONS

The notion of bioclimatic design is used to describe the control and enhancement of environmental parameters in designing spaces which ensure thermal comfort. It includes the maintenance of as much natural elements in the landscape (i.e. green and water surfaces) as possible, the development of expanded pedestrian, cycling and green networks as well as the proper orientation of urban elements. Moreover, it concerns the use of 'cool' materials, which have high reflectivity in solar radiation and thermal emission.

The bioclimatic street is mainly a street friendly to the environment, limited in conventional road surface and made of materials with low absorption of solar energy. Space for automobile is minimized, allowing usually only local traffic, while most of the other surfaces are covered with materials such as light granite and greenery. Those streets have been characterized as 'coolness oasis' as they increase the level of thermal comfort and reduce the needs for air-conditioning. The light presence of cars as well as speed reduction, due to the traffic calming measures that are usually applied in such streets, ensure low exhaust emissions, achieving a rather ideal microclimate in the city level.

3.3 THE ROLE OF PAVING MATERIALS. TEMPERATURE, REFLECTANCE AND NOISE.

Geometry, texture and structure of road materials affect the temperature, reflectance and noise levels of the street environment. For example, complex and rough surfaces tend to absorb more radiation than flat and smooth surfaces of the same material. Colours play an important role, too. Simply stated; dark materials can be twice absorbent compared to the light ones.

All types of materials, including those covering sidewalks, public spaces, road surfaces participate largely in the identity of the city temperature. The systematic use of asphalt as the main paving material of roadways, a material largely heat absorbing, results in particular increase of road temperature. Asphalt, similar to other dark materials, develops -during summer months- temperatures around 60^o to 80^oC. On the contrary, other materials of high reflectivity, develop temperatures much lower, in a range of 25 ^{o} to 45 ^oC. Table 1 below indicates solar radiation absorption for different materials; the first factor affecting temperature increase.

TABLE 1: Solar radiation absorption (%)

MATERIAL	Solar radiation absorption (%)
Asphalt	**93**
Dessert	75
Grass	**67**
Thin layer of snow	31
Fresh snow	43
Frozen snow	33
Beech leaves	**71**
Dry sand	82
Wet sand	91
White sand	45
Water, when sunlight angle to the vertical is:	
50°	90
60°	84
70°	74
80°	53
Rural farming	75
Deciduous forest	85
Coniferous forest	95
Reinforced concrete	**55-80**

Noise disturbance on the street level is generated by engine operation and roadway sounds related to wheel contact with the paving materials. The evolution of technology has managed to decrease engine sounds at a considerable level, though structural amendments in tire textures have not reached significant results yet. Consequently, solutions are sought in increasing sound absorbing materials and replacing traditional ones. A porous paving material gives way to air trapped between wheels and road surface, so given the complexity of the pore space (i.e. granulometry with light inconsistencies), a more effective noise entrapment can be achieved resulting in a minimum of 3dB(A) reduction.

Hence, in order to turn conventional streets into bioclimatic, materials play a key role.

Research on the issue shown that the use of cool paving materials is imposed. Cool pavements include a range of established and emerging technologies which reflect more solar energy, have high emissivity in the short-wave infrared and enhance water evaporation. They are created with existing paving technologies (such as asphalt and/ or concrete) as well as newer approaches such as the use of coatings or grass paving. The later approaches in technology of pavements are photocatalytic materials. Photocatalytic materials are innovative products used in urban areas, covered by international patents and certified by recognized European and international scientific laboratories. They have been designed and produced by Global Engineering and Group Italcementi, distributed in numerous countries by recognized agents. They consist of non-toxic materials such as cement and they offer unique advantages: reduce environmental contamination and self-clean surfaces, while enhancing the aesthetic character of streets. They also tend to suppress algal growth and present crucial antibacterial effects.
According to the specific location, they are suggested to be used in sidewalks (i.e. blocks or cobbles of natural granite) as well as on road surfaces (i.e. photocatalytic coatings), addressing widely urban heat island effect. It is worth mentioning that natural granite's reflectivity is about 0.47, which is considered sufficient enough to achieve the desired reduction in temperature, while the photocatalytic coating reflectivity can vary from 0.40 to 0.60 depending on its colour.
Particular choices can be made after special measurements according to the following methodology presented in this paper.

3.4 TRAFFIC CALMING IMPLEMENTATION AND THE ROLE OF VEGETATION

The starting point of a bioclimatic street regeneration though, is not the replacement of conventional materials with cool pavement, but rather the implementation of policies and specific measurements to enhance pedestrian and cycling mobility in the city, which is a complete change to the current urban and transport planning culture. In other words, the promotion of sustainable mobility policies is crucial to reduce air and noise pollution as well as increase the thermal comfort of a place. Traffic calming techniques, such as street narrowings, chicanes, curb extensions, chokers, pedestrian refuges, one way convertions et cetera, are applied in order to reduce vehicle speeds (average 30km/h), improve safety and enhance quality of life. This type of urban and transport planning prerequisites a different approach in street hierarchy according to land uses, key centralities, public transport network and many more urban factors which focus on the original goal; altering of motorist behavior in favor of the city and consequently street livability. Street modification that incorporates traffic calming policies, apart from tackling traffic volume, aims at transforming typical road spaces into public places, increasing sense of place and neighborhood character.
Vegetation is a determinant factor in bioclimatic street design and a necessary tool in traffic calming applications, working as heat absorbent, landscape element and creating the visual cues that encourage people to drive more slowly. It is the basic attribute in most traffic calming tools (i.e. chicane islands, chokers, pedestrian refuges) working also as a parking arrangement feature and a beautifying element adding on the attractiveness of the streetscape.

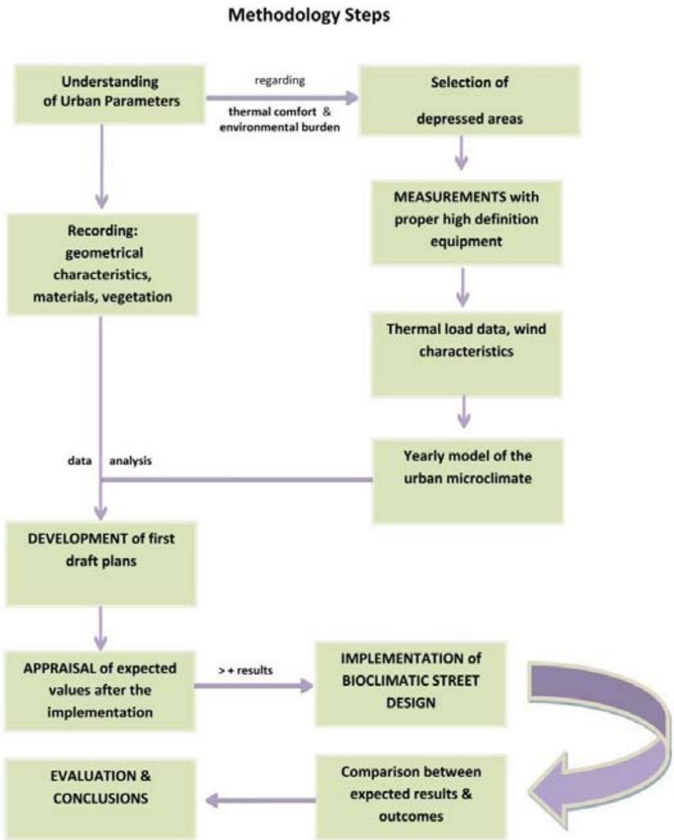
4. METHODOLOGY DEVELOPMENT

Turning a conventional street into a bioclimatic, prerequisites a number of tasks regarding the existing situation study. Basic issue for applying the described methodology is the understanding of the various parameters affecting thermal comfort and environmental status in the urban environment. Another determining factor is the proper selection of most depressed zones or those potential according to their urban morphology to be regenerated in the direction of bioclimatic design. The methodology described below can also be seen in the following diagram (Diagram 1).

The overall data of microclimate parameters is selected through measurements regarding its thermal comfort and environmental burden . First of all, an analytic recording of the existing situation takes place, related to the detailed geometrical characteristics, materials, vegetation etc. Through appropriate equipment (thermal cameras, thermometers, hygrometers, anemometers), thermal load and wind attributes data are collected in specific locations along with annual climatological data, used to assess the urban microclimate. Following the data collection, places with higher environmental burden and increased heat absorption are determined , while the analysis of traffic and urban characteristics is developed. According to the above analysis, the first draft plans for the design of the street are generated, concerning the new road morphology as well as new paving and coating materials and vegetation design. As the aim of this scheme is to optimize urban microclimate in the street level, the model appraising thermal comfort, PM concentration and wind characteristics are being run with the expected values after the regeneration project study. If the model results are encouraging, the project is being led to implementation and thereafter measurements are repeated in order to be reviewed. Comparisons are made between previously expected and resulted values so as to optimize the model and draw conclusions about the development process.

An example of implementing the above methodology is described in further detail in the following chapter 5 regarding Papandreou street.

DIAGRAM 1: Methodology steps



5. IMPLEMENTATION CASE IN NEW ERITHREA

5.1 PERSPECTIVES- OVERALL ANALYSIS

After thorough bibliographic research and analysis of intervention procedures in street microclimate, the research group focused on a case study in order to evaluate and confirm the intended outcomes.

The study area is New Erithrea, a municipal section of Kifissia, located in the northern suburbs of Athens originally built to accommodate refugees from Asia Minor around 1923. Nowadays, it expands in an area of 6.5 km² inhabited by almost 15.500 people. During the last 10-15 years the area has been under rapid urbanization and has developed significant social and cultural activities accompanied with their relevant infrastructure and utilities. The above growth has affected numerous residential neighborhoods in the area, regarding insufficient traffic and parking management, noise and environmental pollution and increased thermal load among others. The regeneration scheme was decided to be implemented at a strategic part of the road network, a wide street (~ 20meters) with particular layout and residential uses, serving both inner- neighborhood and through traffic, as it remains the key parallel of the main thoroughfare in the Municipality of Kifissia. Moreover, the importance of this artery is due to its previous rail operation as the train to Penteli mountain was using part of it. Before the study, Papandreou Street was a two- way street, with one(1) meter wide sidewalks on each side and eighteen (18) meters road surface (Image 1 &2), divided with a narrow median!

Image 1 &2 : Papandreou Str. before bioclimatic modification

On the main roadway (the 18meter section), there were; traffic lanes- one in each direction-, informal parking lots; angled, oblique or parallel in places and an one- meter median. Vegetation was present, though essentially disorganized and pedestrians were displaced in small shattered sidewalks. The environmental status of the street zone, regarding both pollution and thermal comfort, is described in the section below, as resulted from particular measurements and the overall evaluation of the study area.

5.2 DATA ANALYSIS

The sample of data presented in this chapter is related to environmental facts and urban characteristics. Important measurements are related to the recordings of spatial temperature distribution where the actual thermal load is depicted through thermal cameras and specific correlations are made regarding the thermal absorbance of materials. The basic research attributes are presented, such as the period of measurements and the equipment used, letting out detailed references for space economy. The aim of this recording was to investigate all the parameters affecting thermal comfort in outdoor places.
The various climatological data recorded were related to temperature, humidity, wind speed and direction as well as particulate air pollution in regard to the traffic load. Moreover, thermal performance of each material (i.e. coating materials, buildings components, green spaces) is investigated though its surface temperature.
Measurements were taken in the perimeter of the study area for a period of 10:00-17:00 hour in the 10th of February 2009, through a portable meteorological station, an AGEMA Thermovision 570 infared camera, thermometers T351-PX 1/3 DIN with PT100 sensors, Tinytag thermometers and hygrometers, A100K Pulse output and W200 Porton Windvane anemometers, while in order to capture the levels of particulate pollution Osiris machines

have been used.
Measurements showed that during the day the heat burden is higher in midday hours (12:25 to 14:30) and overall surface temperatures are rather low (due to winter season) ranging from 3 to 9 ° C higher than the air temperature. Large differences appeared through comparisons related to temperature of shaded and unshaded materials such as sidewalks, road surface, and buildings (Table 2).

TABLE 2: Minimum and maximum surface temperatures in relation to shade

LOCATION	PAPANDREOU STREET	
	average	max
Road (unshaded)	17.7	19.8
Road (shaded)	8.8	11.7
Buildings (unshaded)	16.4	18.1
Buildings (shaded)	10.2	13.7
Sidewalks (unshaded)	16.8	19.3
Sidewalks (shaded)	10.5	11.5
Vegetation (unshaded)	10.8	-

Furthermore, regarding measurements of particulate air pollution, highest concentrations of PM10 are seen in the early morning hours, but without exceeding the permitted limits.
The average surface temperature of unshaded road surface was 17.7 ° C, while the maximum value 19.8 °C. Obviously, highest values appear on roads since the average surface temperature of unshaded sidewalks was found to be 16.8 °C, with its maximum on 19.3 °C. Comparisons resulted to large temperature differences ranging from 6.0 °C (sidewalks) to 8.0 °C (road), which were extensively considered in selecting the appropriate materials, according to the specific location.
A sample of thermal radiation (Image 3) and spatial temperature distribution (Image 4) are presented below depicting clearly among others the role of vegetation in reducing heat absorption .


Image 3: Illustration of Papandreou Str. through infrared and visible radiation


Image 4: Spatial Temperature distribution in Papandreou Str.

Apart from the above, previous urban and traffic characteristics were fully studied such as road and sidewalk sizes, urban green, lighting, drainage and garbage can locations etc., in order to provide a complete regeneration proposal that would decrease car presence and enhance neighborhood's identity.

5.3 INTERVENTION ATTRIBUTES

A bioclimatic regeneration scheme should tackle the street environment in two complementary ways; turn it into a sustainable street in terms of urban and transport planning characteristics and create the best possible thermal equilibrium for people and street elements. This prerequisites the modification of the street use; in other words, the prioritization of vulnerable users and the development of a healthy and attractive environment.

In the case of Papandreou Street in New Erithrea, the above was achieved through a number of tasks and its current situation confirms the initial goals of the development. The conventional street section (sidewalk-road- sidewalk) is being dismissed and space becomes more complex. Each street section serving an activity is being paved with a different material (i.e. road surface, bicycle land, pedestrian path, green corridor, parking lots) and the distribution of street users becomes more perceptible as illustrated in the street section below (image 5).

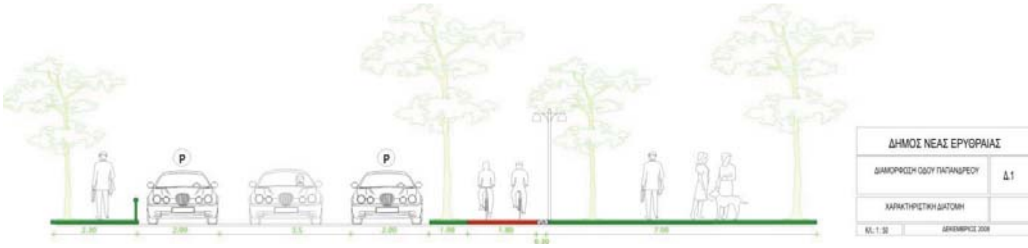


Image 5: Papandreou street section_ Regeneration proposal

Two-way street is being converted into one-way, on-street parking is arranged in parallel to sidewalks in both street sides with vegetation intervals in chokers, a 2-meter cycling lane is located on the one side, vegetation is upgraded and sidewalks are enlarged. Intersections are being re-arranged with curb extensions, ground is elevated in the sidewalk level and different material is used in order to achieve visual diversification.

The outline of the main roadworks is as follows:

The existing pavement is being removed and light colour granite is placed instead. Trees and low vegetation are located in the designated areas. Bollards are placed to prevent illegal parking and garbage containers are placed underground in specific locations. In order to avoid aimless steps and ramps, street elevation is being unified in the pedestrian level. Moreover, appropriate signs are installed to indicate the new traffic status and stimulate the new use of space. The proposed cool materials range from light colour granite with photocatalytic coatings to cobbles and concrete blocks. Image 6 presents the implementation phase of the project and image 7 the current setting after the completion of roadworks.

Image 6: Roadworks in Papandreou street

Image 7: Current setting of the first bioclimatic street

5.4 RESULTS

According to the planning study and the measurements taken before the implementation of the project, data were evaluated through a simulation programme aiming at assessing the outcomes of the proposed scheme. The expected average air temperature reduction was 3°C, which is expected to contribute significantly to improved levels of thermal comfort. It is estimated that a 3°C reduction of air temperature is sufficient to decrease the energy lost in air-conditioning (cooling) systems by 10% to 15% as well as increase by 20% to 25% the level of thermal comfort in outdoor places.

Moreover, traffic load has been reduced by 75% and streetscape has been upgraded both aesthetically and operationally. Papandreou street has been transformed into a more social, human -scale and gathering place; a safe environment for vulnerable road users. It is worth mentioning that the regeneration somehow 'tempted' residents with their building facades on Papandreou Street to renovate their patios and gardens to 'match' the new urban environment.

Lastly, confirmatory data collection -although less detailed- has been completed in a short period after the implementation, showing a temperature reduction of 2.8% -3% and an average increase in thermal comfort reaching 20%, proving the liability of the regeneration project and the potential benefits in the neighbourhood scale.

6. CONCLUSIONS

Thermal, visual and acoustic comfort along with many other parameters, such as social and spatial justice aim to upgrade the quality of life in cities. The challenge in contemporary planning schemes is to incorporate environmental aspects and avoid solely beautification designs while improving the strained road environment from car domination. The proposed methodology for bioclimatic street design attempts to combine the above principles and approach the regeneration procedure in a holistic and concise way;

- ensuring improved microclimate conditions
- serving operational needs of the street environment

- strengthening social role of public space

However, there is a number of issues that can be considered problematic in regard to these type of schemes usually related to economic assets and public compliance. A characteristic example -as seen in the case of Papandreou street- is the reaction of neighbors from the wider area who perceived the project as a means of unequal development and regarded that some streets are turned into privileged zones, forcing neighboring lands to accommodate both the environmental and traffic burden. Moreover, the economic aspect of this development raises a crucial issue as bioclimatic street design prerequisites high cost materials and periodic maintainance works, due to their small lifecycle (i.e. photocatalytic coating has a lifecycle of 3-5 years). However, the counterveiling benefits of such an investment in terms of environmental quality prove the need for a reconsideration of resources utilization, even in times of economic hardship as seen currently in Greece.

As a land tool the proposed methodology identifies all the key issues regarding place identification, data analysis, implementation and confirmation of outcomes, revealing a research interest that has little been analyzed. Bioclimatic street design -compared to the well researched subject of bioclimatic architecture design in buildings- has been limited so far to materials, letting out parameters of geometrical characteristics of spaces, issues of sustainable mobility and social aspects of places. The presented implementation case, together with the methodology proposed, can be used as a good case practice in numerous strained zones especially in south European cities which present similar specificities in terms of thermal comfort in their urban environment.

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