URBAN GARDENS: AS A SOLUTION TO ENERGY POVERTY AND URBAN HEAT ISLAND

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ABSTRACT

Urban gardens are a means of greening and are created by a local community. As regards any urban environment, urban greening helps cooling the air and provides shading, thus reducing building energy consumption and improving the outdoor conditions during the summer. In more detail, vegetation is a way to deal with the phenomenon of energy poverty in which many people cannot meet their basic energy needs as well as the phenomenon of urban heat island. This paper deals with the ways in which vegetation affects the improvement of microclimatic change, mainly through evapotranspiration. This is examined in a region of the city of Chania. More specifically, through the application of Envi-met software the current condition, a scenario with absence of vegetation and two scenarios of different vegetation are analyzed. In the last two scenarios fruit and vegetables and agro-biodiversity like herbs, which both are consumed, are used.

KEYWORDS

Energy saving, Urban Heat Island, Environmental planning, Urban green space, Community Gardening

1 INTRODUCTION

The increasing accumulation of people in cities combined with the urban heat island effect creates an urgent need to create green spaces within them. Greening is a natural method that brings many advantages depending on both techniques used and the purposes to be served.
This research concerns the creation of green urban spaces in the city of Chania, and more specifically the creation of urban gardens.

1.1 Urban Climate

The climate in every region of the globe can be described at three different levels, going from the general to the specific, from the largest scale to the smallest: the macroclimate, the mesoclimate and microclimate. The macroclimate of an area is about the general climatic characteristics and is defined by climatic conditions, such as temperature, solar radiation, sunshine, wind, humidity, clouds and rainfall. The mesoclimate of an area is the transformation of macroclimate due to local circumstances, such as the terrain, the existence of large areas of water and vegetation. The microclimate of an area is the diversification of macroclimate and mesoclimate, mainly due to human activities. (Boutagioti et al. 2009)
The continuous upward trend of agglomeration in urban centers is expected to increase the population of people living in urban areas by 60% in 2030. (Mirzaei and Haghighat 2010)This has resulted in human exposure to microclimate, specifically in "urban microclimate."
The term urban microclimate means the climatic conditions prevailing in an urban area (square, park, neighborhood, etc.), which can show significant differences compared to the

conditions prevailing in the wider area. The urban topography affects these microclimatic conditions, since it determines the shading and the flow of air between buildings to a ;arge extent.(Mirzaei and Haghighat 2010)

1.2 Urban Heat Island Effect (UHI)

Air temperatures in densely populated urban areas are higher than the temperatures of the surrounding areas. The phenomenon is known as the "heat island" effect and is the most obvious climatic manifestation of urbanization. (Santamouris et al. 2007) The causes of this phenomenon are mainly produced various sources such as anthropogenic heat, traffic, lack of green space and the construction of an urban center.

1.3 Energy poverty

According to the Greek Article 24 paragraph 1 of the 1975 Constitution there was a provision according to which, "the protection of the natural environment is an obligation of the State and a right of everyone." The right to a proper environment implies a right to energy. However, nowadays, many people are unable to meet their energy needs and even the essential ones, as it is the electricity. This phenomenon is called "energy poverty" and appears more and more as time goes by.

Energy poverty is the difficulty or inability to maintain housing at appropriate temperature (as a point of reference could be the definition used by the World Health Organization, according to which the proper temperature in the living room is 21 º C and in the other rooms 18 º C, or any another technically adequate definition) and other essential energy services: lighting, transport or electricity to use the Internet or other systems and devices. (Gazette 2011)

1.4 Biodiversity

It is obvious that in recent years there have been enormous changes in natural ecosystems. The shift of people towards urban centers, the removal of the natural environment and daily activities have led to threats to biodiversity. According to the Intergovernmental Panel on Climate Change (IPCC), human activities until 1750, were blamed for the global warming. At the same time, they argue that it is likely that 20-30% of plant and animal species will become endangered if the average amount of global temperature increase exceeds 2.3 ^{o}C. The escalating extinction crisis shows that the diversity of nature cannot support the current pressure that humanity is placing on the planet (Pia Drzewinski 2012)

The links between poverty, climate change and biodiversity are very important.

- Land use changes, leading to habitat and thus biodiversity losses, can also boost greenhouse gas emissions. (Reid and Swiderska 2008)
- Poor people are disproportionately vulnerable to the loss of biodiversity and ecosystem services. And although they are responsible for emitting the lowest levels of greenhouse gases, they suffer most from the impacts of climate change. (Reid and Swiderska 2008)
- Geographic location is a key factor in the vulnerability of poor people and poor nations. Many of these countries lie in the regions most at risk due to climate change. (Reid and Swiderska 2008)
- Biodiversity conservation and the maintance of ecosystem integrity are central to improving the ability of the poor to cope with climate change. (Reid and Swiderska 2008)

2 BIOCLIMATIC DESIGN – URBAN GARDENS

In Greece the energy demand grew rapidly after 1990 with main consumers industry or households. The main energy consumption is used for heating and cooling. According to surveys, 41% of the total energy produced is spent in European countries in order to meet buildings requirements for heating and cooling. (Axarli et al. 2008) For this reason, researchers have turned to bioclimatic design. As part of bioclimatic design green buildings, more specifically buildings whose construction and operation manual are environmentally friendly and efficient throughout its life cycle of the building, are developed. A technique of bioclimatic design for both the shell and the outside of the building, which offers better energy building performance, is urban gardens.

An urban garden is land used for growing food from people of different families, usually urban dwellers with limited access to their own land. An urban garden differs from public green spaces because the main characteristic is the familial assistance to produce their own products, vegetables, or medical herbs. (Okvat and Zautra 2011) Looking back in time, urban gardens were developed in the 80's, where cities offered to the poor a small part of land in the city to cultivate their own produce. In New York during the Great Depression nearly 5000 urban gardens were cultivated by residents in order to increase supplies of food and occupy the unemployed. (Okvat and Zautra 2011)

Nowadays that a new economic crisis affects all Europe, the idea of urban gardens is called as a solution to address energy poverty. More specifically, it examines the scenarios of cultivating horticultural or medicinal species in urban gardens (ie areas already cultivated) to lower the temperature and therefore reducing the energy needed to cool buildings.

3 STUDY AREA

3.1 Location

The study area of this research is in the city of Chania, a city located in the northwest part of Crete and the capital of the prefecture of Chania. More specifically, the block to be examined is in the region of Halepa which is one of the most historic districts of Chania, located to the east of the city. Although the area is not the direct central part of the city, it is quite densely built. Its orientation is north.

The block selected consists of five buildings, two of which are block of flats (with several floors) and the rest are smaller buildings (with two or three floors) (Figure 1).

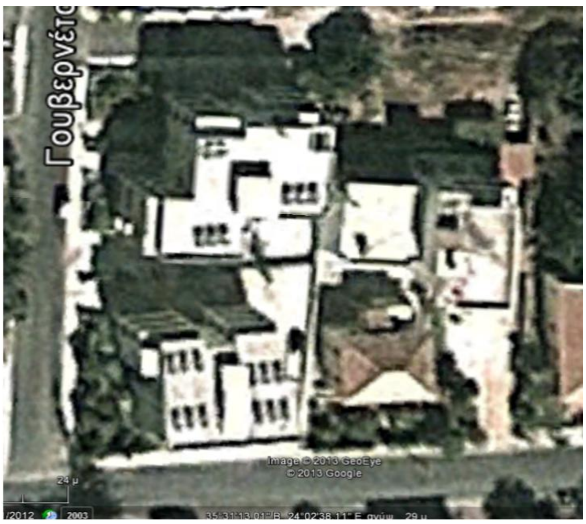

Figure 1: Study area, (*google earth*)

3.2 Climatic characteristics

The city of Chania and the region of Halepa have a typical Mediterranean climate: hot summers and mild winters. The area is also characterized by strong winds.

4 METHODOLOGY

The creation of green spaces is a technique that has been applied in the past in other studies. In those studies, as well as, in the particular one the modelling program Envi-met is used, with the difference that the concept of urban home-gardening is used and different installation scenarios and problems to address are examined.

4.1 Use of Envi-met

Envi-met is a three-dimensional microclimate model designed to simulate the interactions of the surface, plants and air in an urban environment. The spatial resolution allows the simulation of the interaction on a small scale. Envi-met is a prognostic model and is based on the Fundamental laws of fluid dynamics and thermodynamics.

The technical aspects and modules used in Envi-met are given below. (Michael Bruse & Team 2010)

Table 1: Aspects and modules of Envi-met software, (*Envi-met manual*)

Atmosphere	Soil System	Vegetation	Surfaces	Biometeorology	Behind the scenes
Wind	Temperature	Foliage temperature	Ground Surface Fluxes	PMV-Value The climBOTs	The Mathematics
Temperature Vapor Turbulence Pollutants	Water Flux Water Bodies	Heat exchange Vapor exchange Water Interception Water transport	Fluxes at Walls/Roofs Heat transfer through Walls		

The first step in order to use Envi-met is to create the area input file. This file combines the position and height of buildings, position of plants, distribution of surface materials and soil types, position of sources, position of receptors, database links and geographic position of the location on earth. These characteristics are set by using grids.

The next step is the creation of the configuration file which defines the settings for the simulation to run. These settings are the area input file, the name of the output file, the day the simulation runs, the meteorogical settings and the plant database. The data which were inserted are given below:

Scenarios	Summer	Spring	Autumn
Start Simulation at Day	21.07.2012	21.03.2012	21.10.2012
Start Simulation at time	00:00:00	00:00:00	00:00:00
Total Simulation Time in Hours	24.00	24.00	24.00
Save model State each min	60	60	60
Wind Speed in 10 m ab. Ground (m/s)	1.78	1.75	1.53
Wind Direction (0:N, 90:E, 180:S, 270:W)	0	270	180
Roughness Length z0 at Reference Point	0.1	0.1	0.1
Initial TemperatureAtmosphere (K)	293	293	293
Specific Humidity in 2500m (g Water/kg air)	7	7	7
Relative Humidity in 2 m(%)	50	60	65

In the end, the simulation runs and gives temperature results for every period of the time chosen by the configuration file. For the visualization of the results, Leonardo is used.

4.2 Stages

The survey examined the current state and three scenarios (no vegetation, fruit and vegetables, aromatic-medicinal species) for three seasons, summer, spring and autumn.

The plants used in each scenario are*:

Table 2: Scenarios examined

Scenarios	Vegetation
"No vegation" Scenario	No vegetation into the block, only outside
"Current state"	Ornamental plants, trees, hedges, grass
"Fruit and vegetables" scenario	Vineyard, lemon trees, tomatoes, cucumbers, onions, lettuce, red beet
"Aromatic-medicinal" scenario	Basel, miscanthus, thymus, salvia, hyssopus, oregano

The area input files created for each scenario are shown in Figure 2.

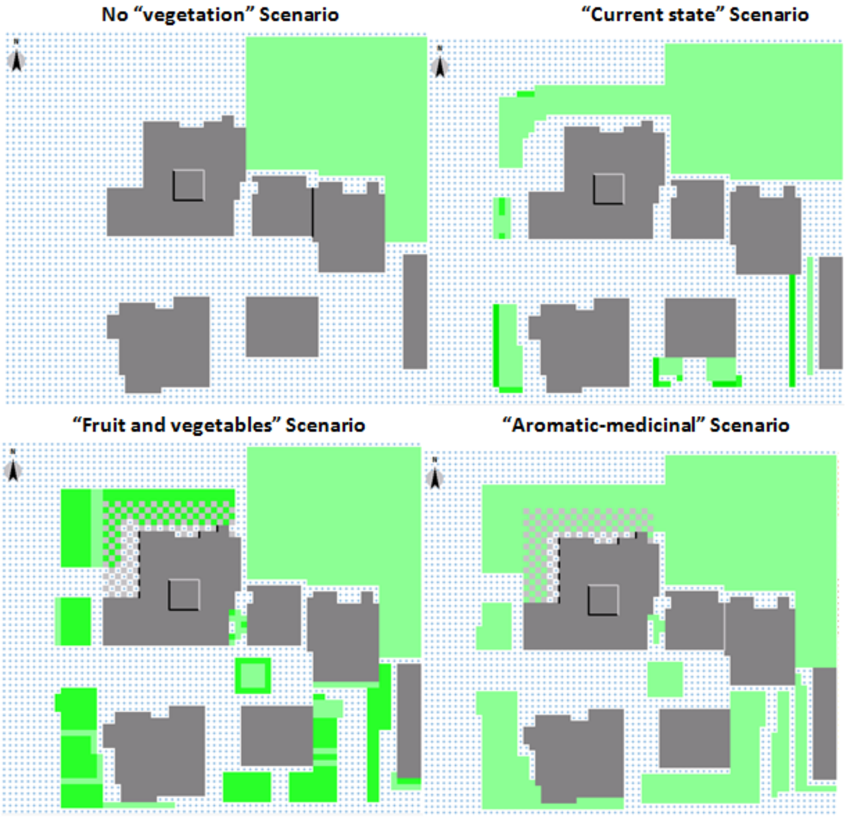

Figure 2 Study area using Envi- met in each scenario

*In order to insert the appropriate vegetation data was used the term leaf area data (LAD).

5 RESULTS

After running the simulation for each scenario summer, autumn, spring, Leonardo is used to visualize the results. The simulation was programmed to take measurements every hour but in the final tablets the results will be presented every 3 hours from 12am to 3 pm.

- **Summer**

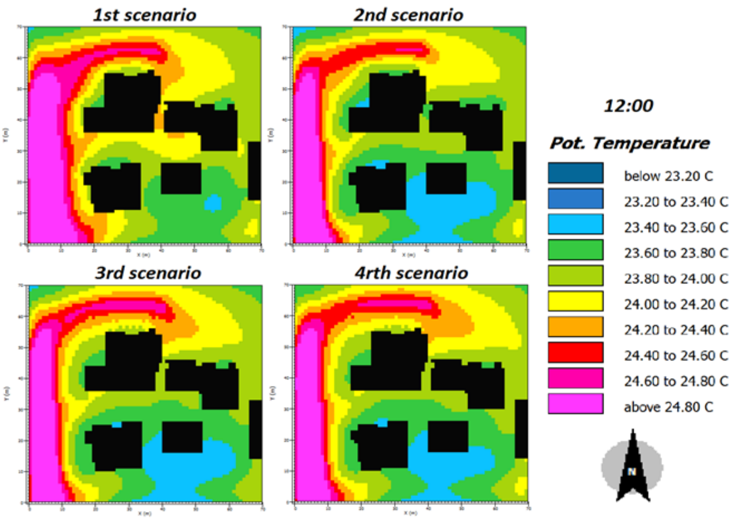

Figure 3 Summer air temperature at 12am

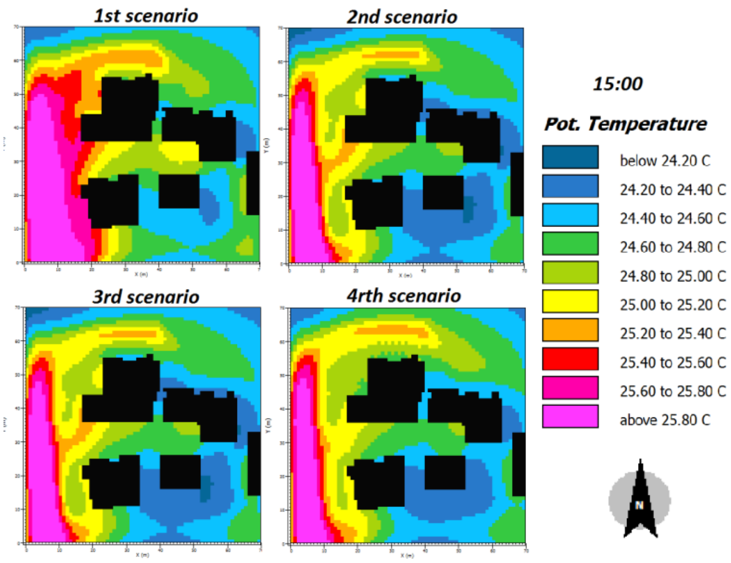

Figure 4 Summer air temperature at 15pm

The results provided above are at 12am and15pm. The maximum air temperature at a height of 1.6 m in these time periods is 26^{o}C and the minimum is below 23 ^{o}C. The temperature variation around the block is not great in any of the scenarios developed. At 12am and at 3 pm the temperature variation in the block is increased to 1.5 ^{o}C. At 12am, at 3 scenarios involving vegetation, temperature drop is felt about the same while at the table of 3pm, the fall in some places between the scenario of zero vegetation and scenario of fruits and vegetables reaches 1 ^{o}C.

- **Autumn**

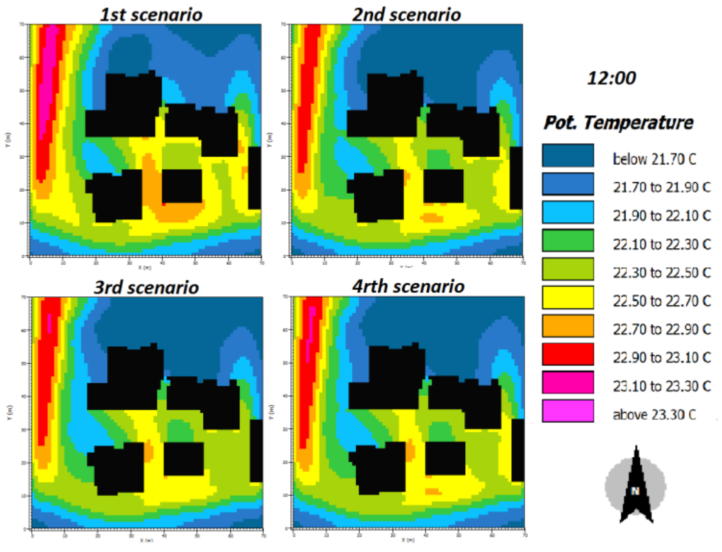

Figure 5 Autumn air temperature at 12am

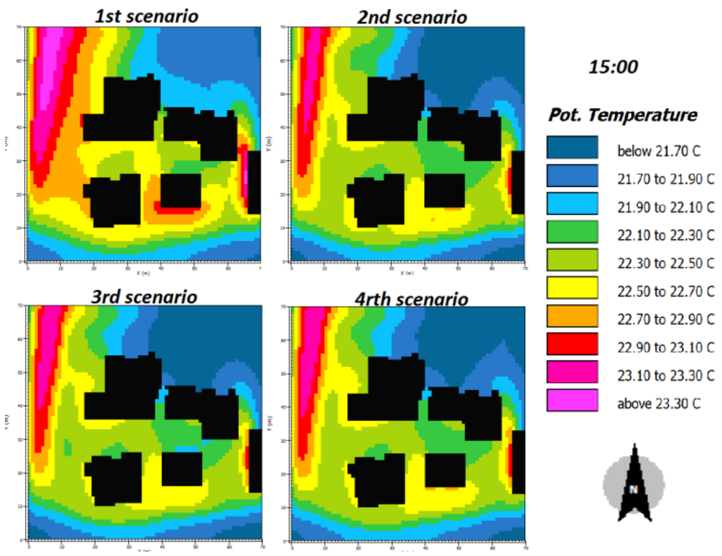

Figure 6 Autumn air temperature at 15pm

The results given above are at 12am and 15pm. The maximum air temperature at a height of 1.6 m in these periods, is above 24 ^{o}C and the minimum below 21.7 ^{o}C. At 12am and at 3pm, the temperature variation in the block is increased to 1.6 ^{o}C and with the same temperatures. In the other two cases greater temperature drop is observed in the scenario of the current state as well as scenario of fruits and vegetables, with 0.2 differences from the other two scenarios.

- **Spring**

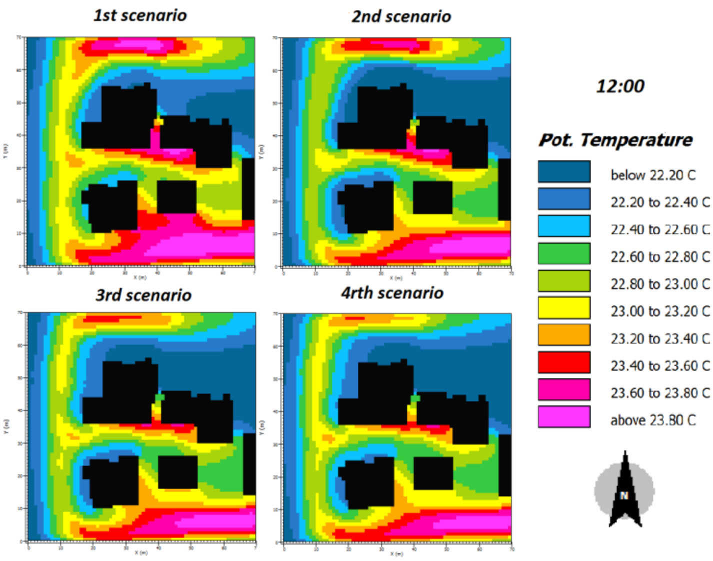

Figure 7 Spring air temperature at 12am

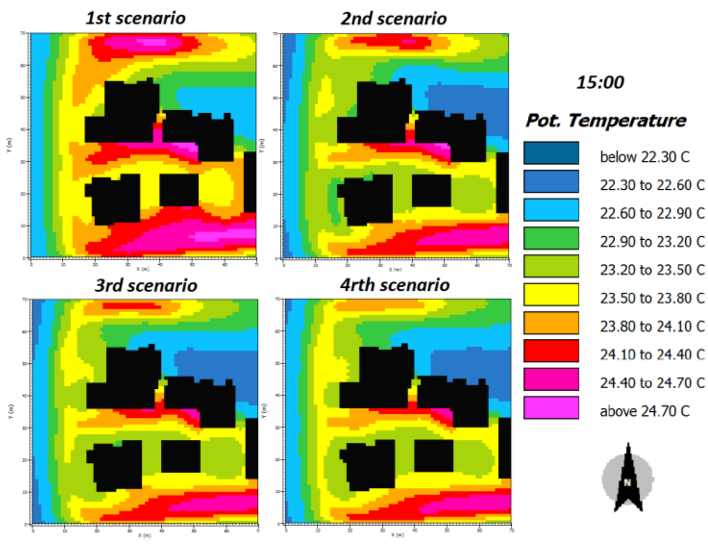

Figure 8 Spring air temperature at 15pm

Th results given above are at 12am and15pm. The maximum air temperature at a height of 1.6 m in these periods is above 24 ^{o}C and the minimum are below of 17 ^{o}C. At 12am, the temperature rises rapidly, with the lowest temperatures below 22.2 ^{o}C and the highest temperatures over 23.8 ^{o}C. At 3 pm, the temperature variation is much more than the typical temperatures frames. In this case there are areas with temperature below 22 ^{o}C and simultaneously areas with temperature above 24.7 ^{o}C. The lower temperatures in this period indicated in the second and fourth in comparison with the other scenarios.

6 CONCLUSIONS

The purpose of the scenarios examined was not to choose a unique scenario as the most appropriate but to create urban gardens with different types of vegetation. The aim of this research is to demonstrate the ways in which the greening contributes to lowering the temperature. It must be noted that in the current state, the measurements are made at a height of 1.6 m above the ground (average human height). So, it was expected that the results will be more satisfactory. However, both hypothetical scenarios are satisfactory (in terms of temperature drop). It may be possible to choose among the scenarios by performing a greater depth analysis, using other software.

The important point of this research is to assist in addressing the phenomenon of urban heat island and energy poverty.

In the first case, the results are obvious, and can be also verified at a local level by making measurements, as the three scenarios with vegetation stand out significantly from zero vegetation scenarios on the thermal behavior.

So, the use and consumption of the products cultivated into urban gardens in combination with the drop of temperature can make the difference according to the surveys carried out. It is a technique of dealing with a relatively new problem that has arisen in recent decades in rapid and natural way.

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