A GIS-based analysis to estimate the benefits of urban green roofs

CITIES FOR US

engaging communities and citizens for sustainable development

Maria Giannopoulou[1], Konstantinos Lykostratis[1], Anastasia Roukouni[2]

Department of Civil Engineering, Democritus University of Thrace, Greece

Department of Rural and Surveying Engineering, Aristotle University of Thrace, Greece

12th International Symposium on Urban Planning and Environment

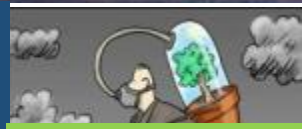
LISBON, Portugal
May 31 - June 3 2016

Outline

- Introduction
- Research Objectives
- Background - Literature review
- Case analysis
- Methodological Framework
- Results and Discussion
- Conclusions and Perspectives

Introduction (1)

- In large urban agglomerations, buildings invade physical space, often aggressively, causing displacement, drainage, pollution and devastation.
- Loss of open and green spaces and their associated advantages for the urban population, a major threat for urban sustainability.
- The urgent need for more urban green space has led to a new tendency worldwide; to create new space on another "higher" level.
- Establishment of another "city above the city", by incorporating the natural aspect to the building itself!




WHAT DO YOU THINK OUR MOST POWERFUL RENEWABLE RESOURCE IS?
DENIAL.


Environmental problems
Convenience store
Energy
Air pollution
Water
Foods
'Anywhere, anytime' trend leads to many environmental problems
High Moon


I WONDER IF THERE'S INTELLIGENT LIFE ON OTHER PLANETS?
YOU MEAN, UNLIKE HERE, ON OURS?...
ACID RAIN
PESTICIDES
CLEAR CUTTING
MINING
DUMPS
NUKES
URBAN SPRAWL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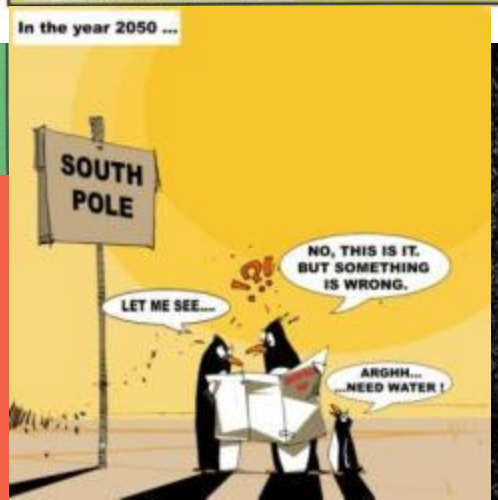
HARDIN
"If you put your ear to them you can hear the land."


In the year 2050 ...
SOUTH POLE
LET ME SEE....
NO, THIS IS IT. BUT SOMETHING IS WRONG.
ARGHH... ...NEED WATER !

Introduction (2)

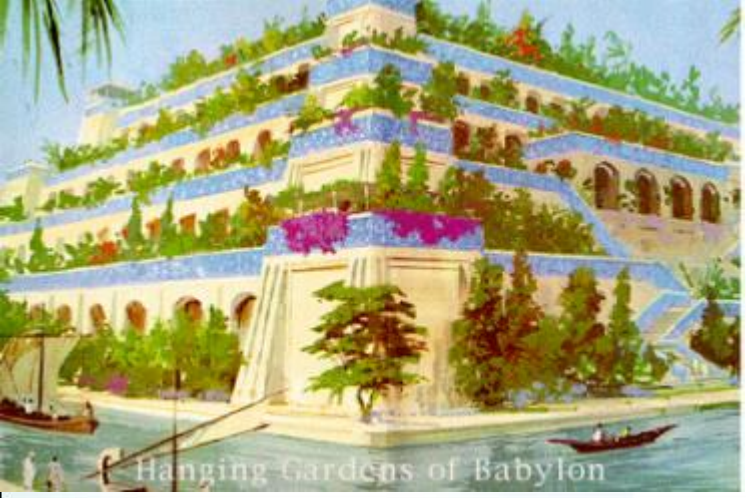
- The idea of planting roofs in order for them to act as natural filters within the urban tissue, has been increasingly recognized as a technology with the potential to diminish drastically many problems of urban centers.
- GIS can serve as a very useful tool as they allow combining many different parameters in a dynamic interactive environment, contributing this way to the effective management and visualization of spatial data.

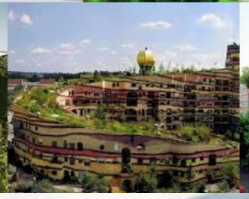
Research objectives

- This paper is part of a wider research still in progress and refers to an in depth analysis of the potential implementation of green strategies.
- The objective of the research presented herein is to investigate and record the impact of the use of green roofs for the development of urban policies which aim at improving the quality of urban environment, using a combination GIS technology and specialized software.
- The methodological framework is applied to a real-world case study of a medium – sized Greek city.

Brief History of Green Roofs (1)

- Green roofs are not based on a novel idea; their origin lies way back in time.
- From the Hanging Gardens of Babylon and Ziggurat in the area of Mesopotamia, to the Celtic architecture examples of the Scottish Highlands during the Middle Age, the concept of creating green spaces above the ground was well-known
- The period of Renaissance enhanced the interest in green roofs, stimulated by the revival of the classical culture and the trend of importing plants.
- Around 1400, the founder of the House of Medici, created a green roof in his Villa in Florence, using a variety of imported plants.
- In the early 20th century, green roof gardens were considered an indication of high quality and luxury, and many leading architects of that time such as Antoni Gaudi, Le Corbusier, followed by Friedensreich Hundertwasser were strong supporters of their introduction.


Hanging Gardens of Babylon



Brief History of Green Roofs (2)

- Since then, a continuously increasing number of cities worldwide have adopted or/and attempted to promote the implementation of green roofs.
- Special laws are introduced which provide citizens with incentives or even involve an obligation to build green roofs.
- In North America, green roof industry grew an estimated 18,5% in 2015, with Washington, D.C., Toronto and Vancouver as leading cities, followed by Chicago, New York, Denver, Baltimore, Seattle and Boston.
- In Asia, many impressive examples of green roof design in Tokyo, Singapore, Shanghai and Beijing, while they are also very popular in Australia.
- European countries with a noteworthy number of green rooftops are: UK, France, Germany, Norway, Denmark, Switzerland, the Netherlands, Spain and Italy.
- EU Directive of 2013 "Green Infrastructure - Enhancing Europe's Natural Capital" -> green roofs as a tool in achieving the sustainable development targets set in the context of Horizon 2020.

Green Roof Types

- Intensive

  Thick substrate layer (20 - 200cm), capable of accommodating a large variety of plants (small trees, shrubs, human paths, water features, sitting spaces etc.) High implementation and maintenance cost, time consuming.

- Extensive

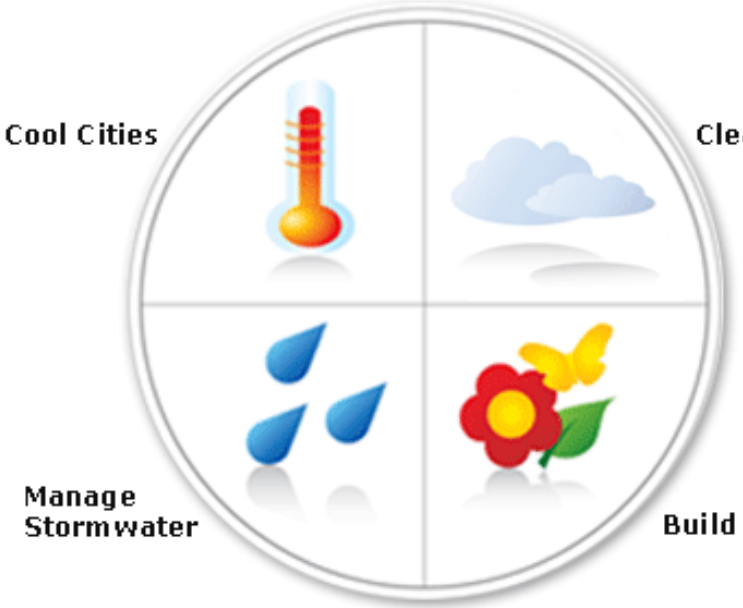
  Thin substrate layer (< 15cm), only "light" vegetation (grass, moss, flowers). Limited maintenance requirements. Preferable type when the rooftop is not easily accessible.

- Semi-intensive

  Incorporates characteristics of both the 2 other types. Maintenance on a more frequent basis comparing to extensive roofs, but still lower requirements than intensive roofs.

Environmental Benefits of Green Roofs

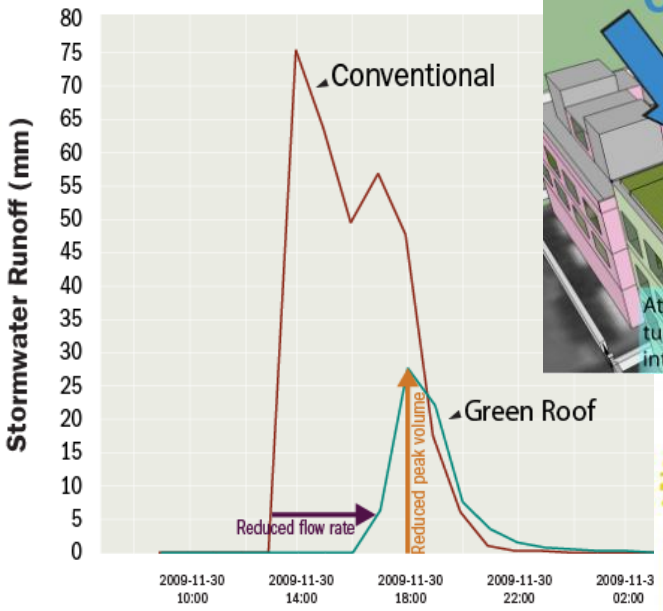
- Improvement of urban air quality
- Retention of precipitation water (storm water management)
- Shelter for urban fauna and flora
- Reduction of noise pollution
- Increase of urban cultivation/farming
- Composting organic waste to fertilize green roofs -> recycling and limit saturation of landfills
- Mitigation of the Urban Heat Island (UHI) Effect

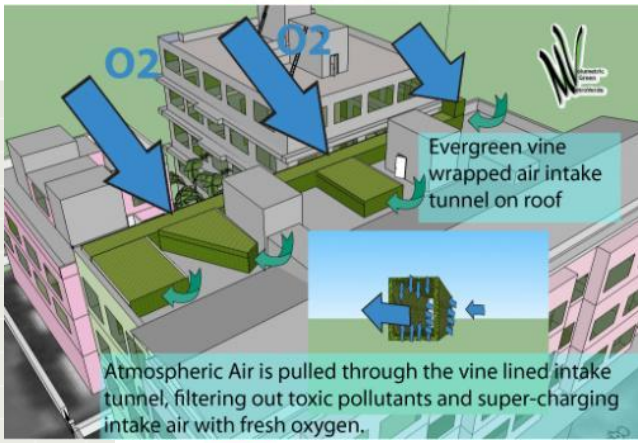


Green roofs help cool cities, manage storm water, clean the air, and build habitat.

GREEN ROOF

TRADITIONAL ROOF

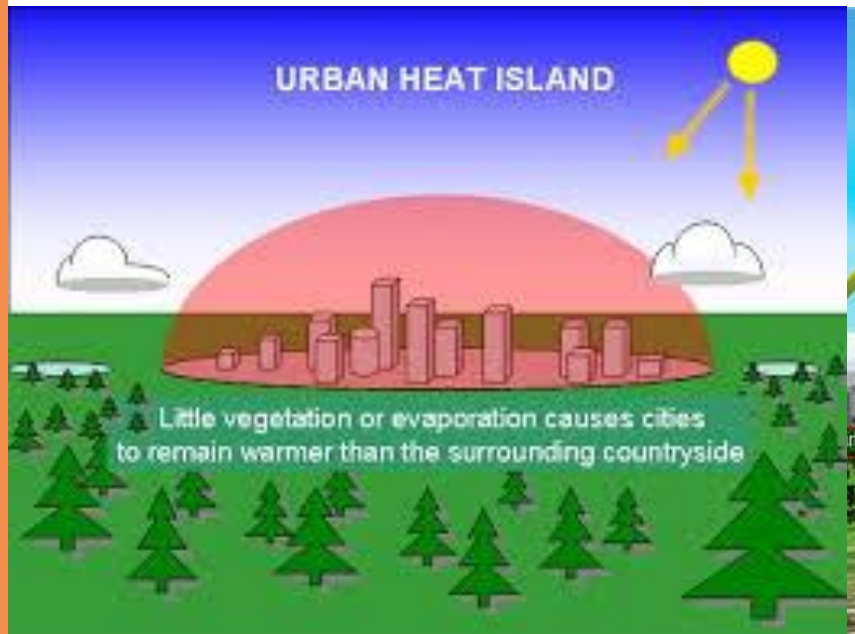


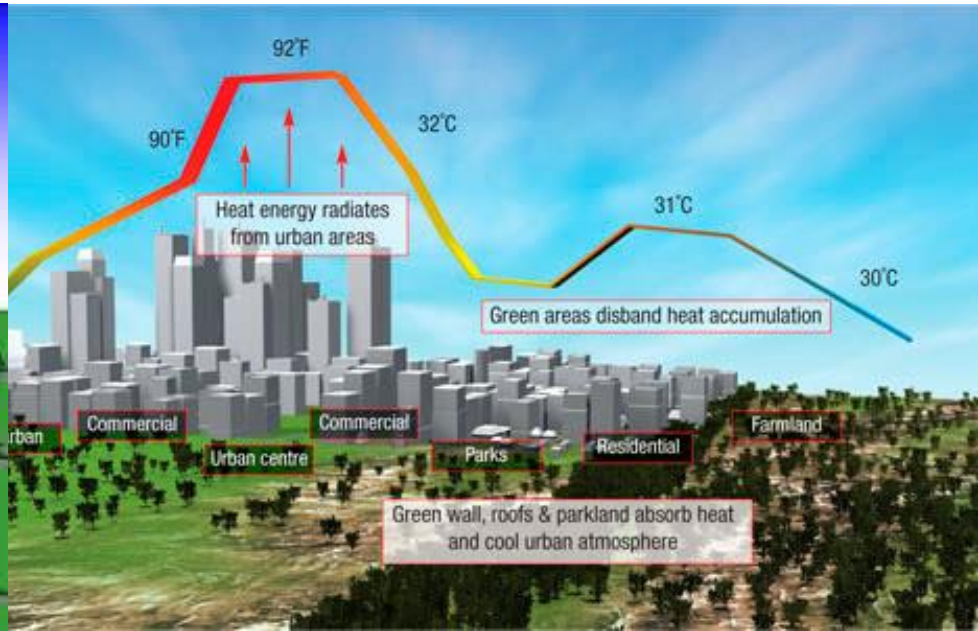



green
roof
shelters

Urban Heat Island (UHI) Effect

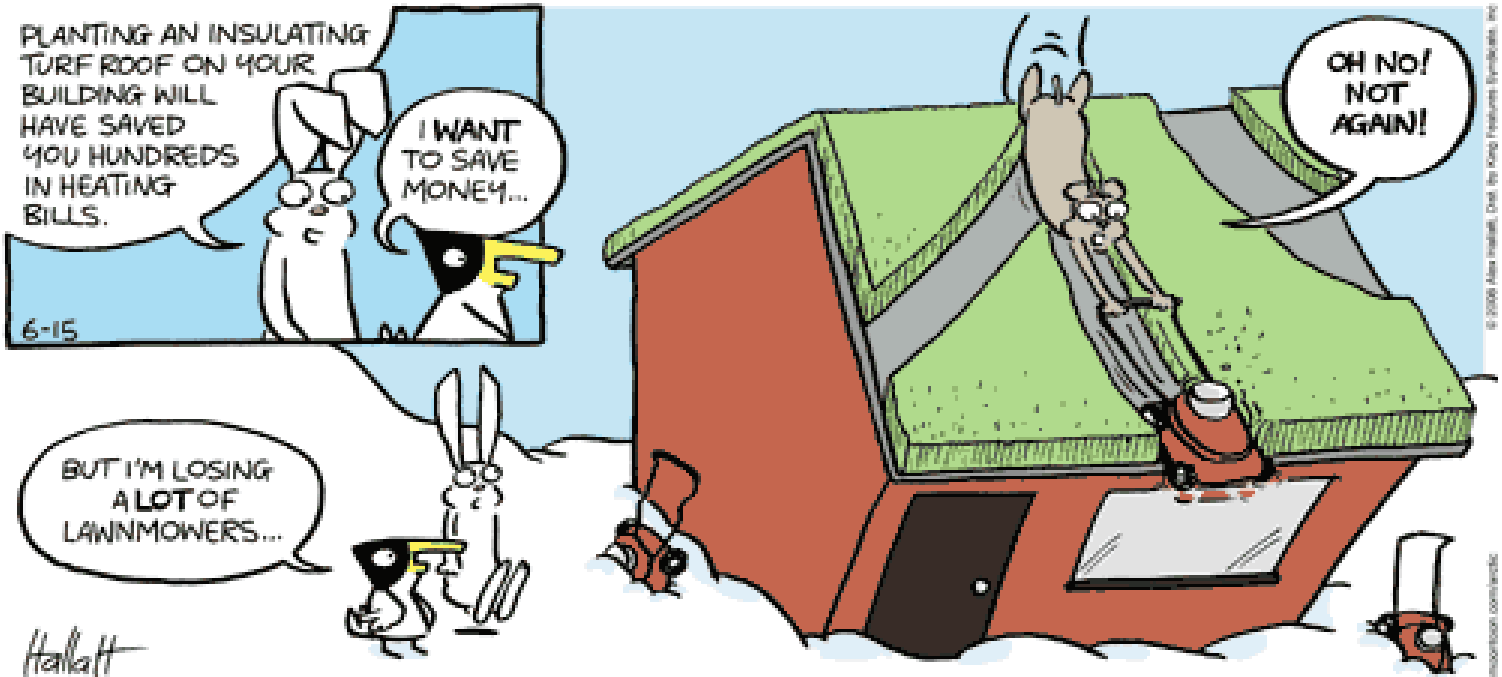
- Increase of air temperature in urban agglomerations of high density, characterized by the replacement of green spaces with asphalt roads and surfaces made of similar materials.
- Urban areas become essentially warmer than surrounding suburban and rural areas, especially during nighttime. The high air temperature in UHI increases the needs for air-conditioning and thus air pollutants' and greenhouse gas' emissions, while favoring the creation of smog.





Economic Benefits of Green Roofs

- Energy savings
- Public sector's health cost savings
- Increase of real estate value of properties
- Reduction of monetary amount dedicated to food purchase



Social Benefits of Green Roofs

- Increase of community space
- Improved livability of cities
- Aesthetic upgrade of urban landscape
- Enhanced social interaction and communication among citizens
- Reduction of stress and anxiety













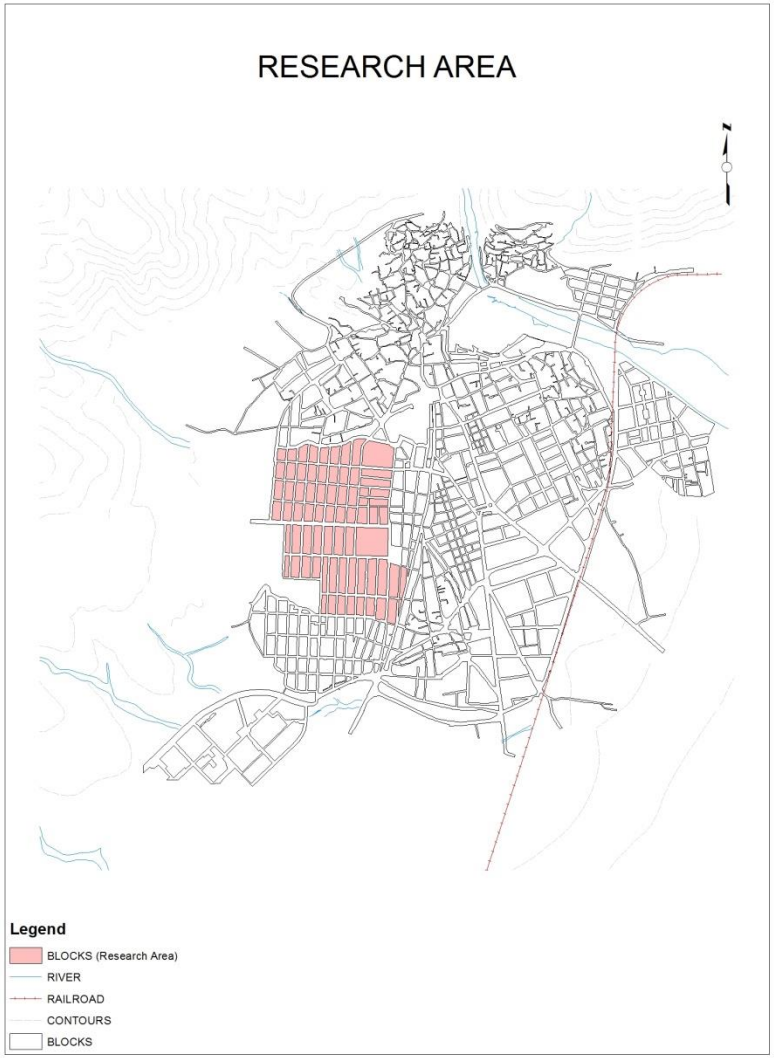
Drawbacks of Green Roofs

- High implementation and maintenance cost
- Need for watering, fertilizing and investment of time
- Structural damage to the building/water leakage
- Fixing/replacing a green roof layer not simple

Case analysis (1)

- In 60% of Greek cities, green and water spaces cover less than 20% of their total area, while in the remaining 40%, it ranges between 20% and 29%, placing Greece in the penultimate position among European countries.
- The New Construction Regulation (2012) aims at increasing green spaces in Greek cities and for the first time refers to green roofs' creation both in new and existing buildings.

Case analysis (2)



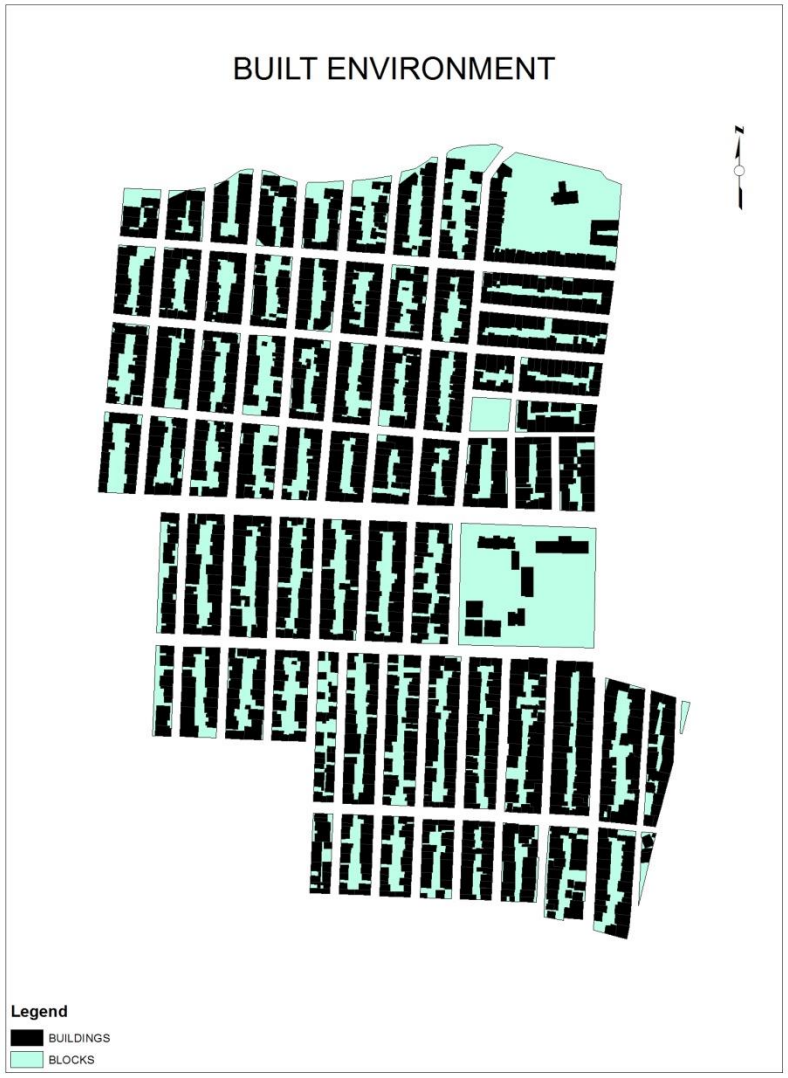
Methodological framework (1)

- Lately, the number of studies which attempt to approach the topic of green roofs and assess their effectiveness based on GIS technology and/or sophisticated modelling techniques has experienced a noteworthy increase.
- In this context a GIS database was created, containing spatial information regarding buildings, blocks, streets and green spaces and descriptive information based on detailed fieldwork recording
- Next step was to exclude the buildings where the application of the green roof technology was unrealistic.

Methodological framework (2)

- Finally, the environmental conditions of the area were modelled using Townscope software platform and the MRT (Mean Radiant Temperature) index before and after potential green roof implementation was calculated.
- The MRT is among the most crucial factors affecting human thermal comfort in an open urban space.
- It is defined as the "uniform temperature of an imaginary enclosure in which the radiant heat transfer from the human body equals the radiant heat transfer in the actual non-uniform enclosure".

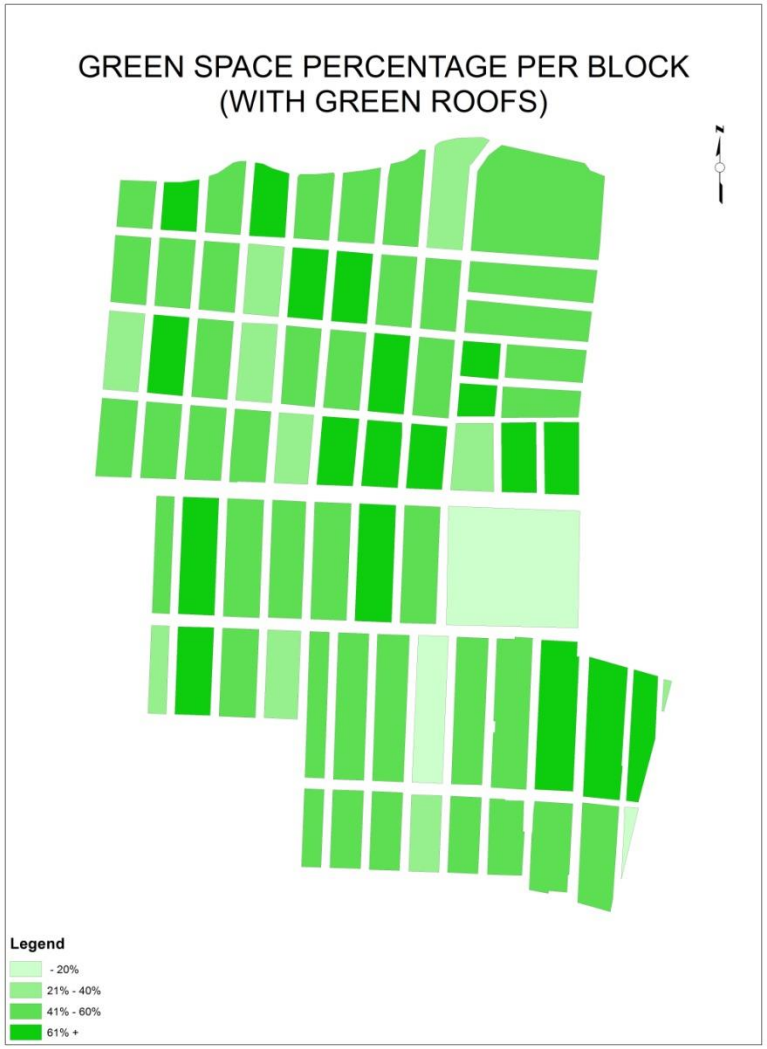
Results and Discussion (1)



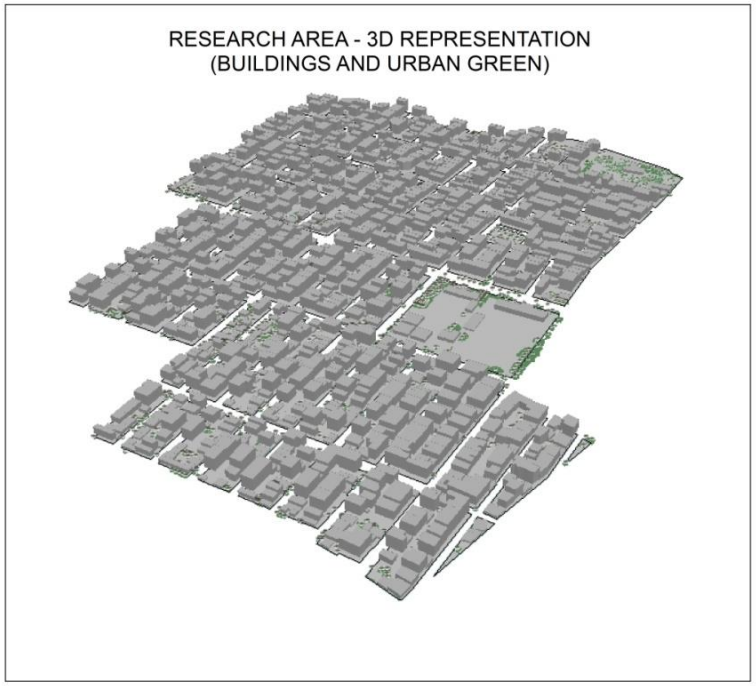
Results and Discussion (2)

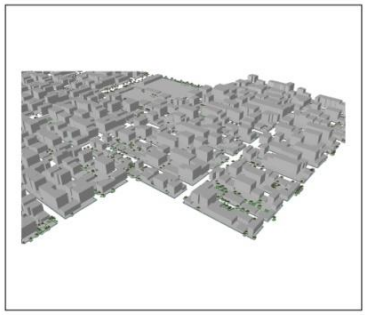
Results and Discussion (3)

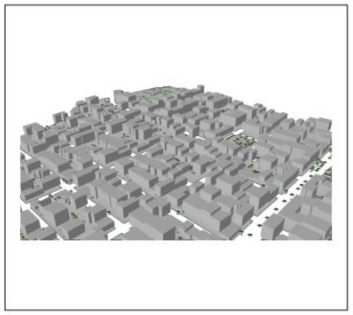
Results and Discussion (4)

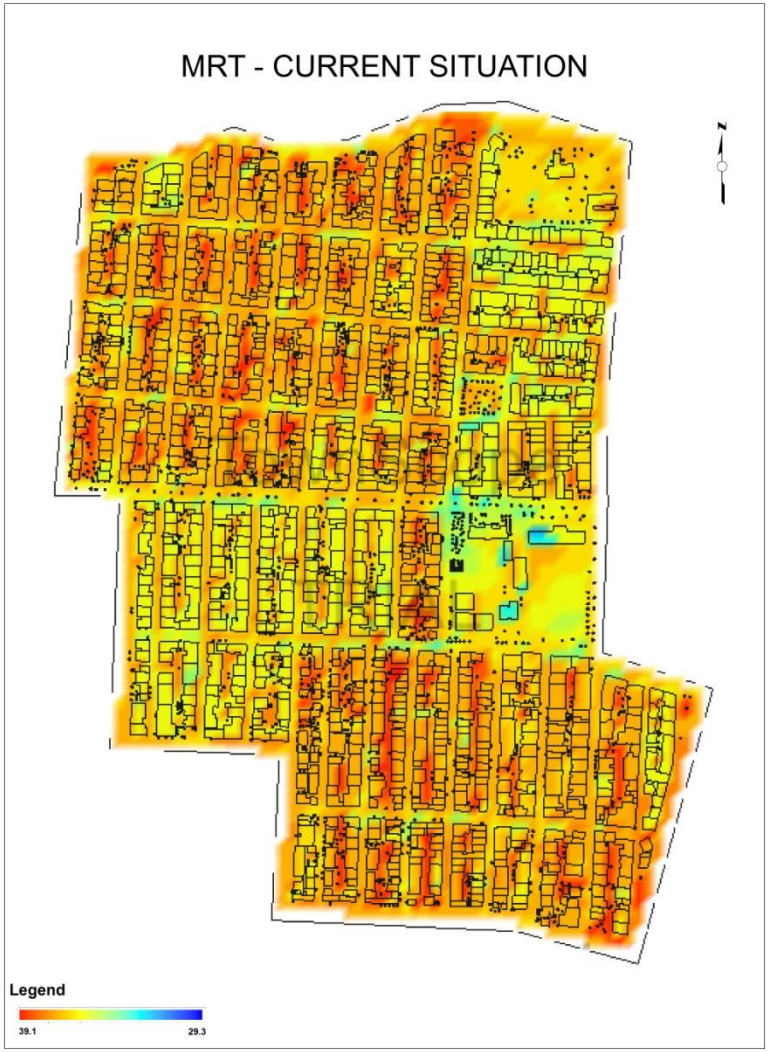


Results and Discussion (5)

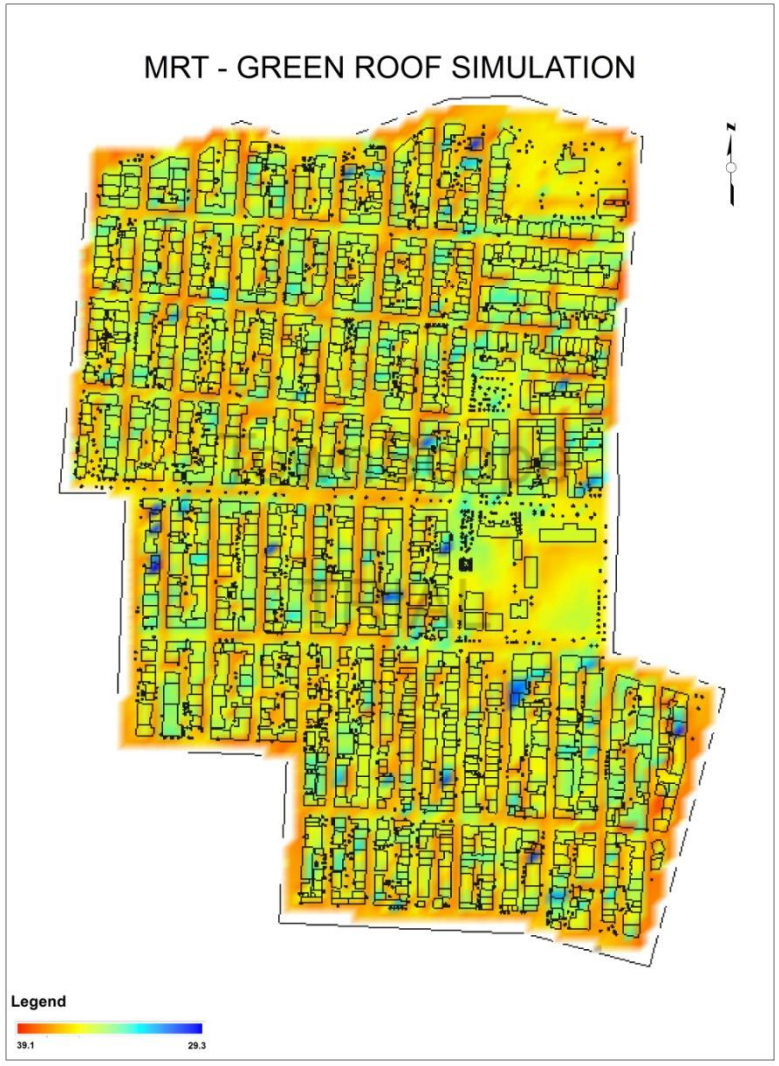


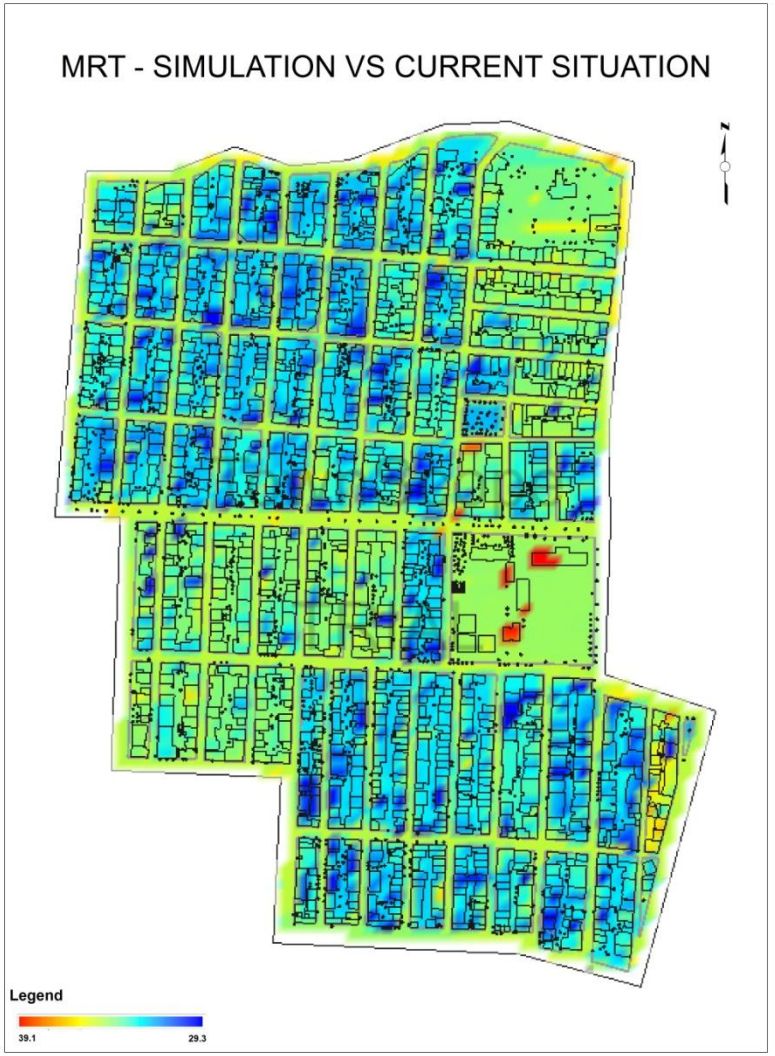






Results and Discussion (6)





Conclusions and Perspectives

The use of a comprehensive GIS environment not only contributes to improving the quality of research but also offers the possibility of continuously updated information and monitoring of the factors that influence development of green roof policies. The collaboration with specialized software facilitates the thorough examination, analysis and correlation of parameters involved, towards the principles of sustainable and smart city development.

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- http://livingroofs.org

Thank you for your attention!

"When one creates green roofs, one doesn't need to fear the so-called paving of the landscape: the houses themselves become part of the landscape."

Freidensreich Hundertwasser (1928-2000) - Austrian artist, architect and philosopher.

natrouk@yahoo.gr
gr.linkedin.com/in/anastasiaroukouni/