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**ORIGINAL RESEARCH PAPER**

# Study of the Urban Heat Island Mitigation Strategies: The Case of Two Cities

*M. Moulai[1], F. Khavari*[2], G. Shahhosseini[3] ,N. Esmailpour Zanjani[4]*

[1]*Department of Architecture, Faculty of Art and Architecture, University of Bu-ali Sina, Hamedan, Iran*

[2]*Department of Architecture, Faculty of Art and Architecture, University of Kurdistan, Kurdistan*

[3]*Department of Architecture, Faculty of Art and Urban Planing, University of Tarbiat Modares, Tehran, Iran*

[4]*Department of Architecture, Faculty of Art and Urban Planing, Islamic Azad University, Tehran-North Branch, Tehran, Iran*

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**ABSTRACT**: Recent studies in urban environment has suggested a new term defined as the Urban Heat Island abbreviated as (UHI) which technically refers to the higher levels of temperature in comparison to surrounding environment due to land transformation and construction of man-made products resulting in many subsequent effects such as transforming the thermal comfort of urban area occupants and etc.. Since the discovery of the phenomenon, many scholars had studied the effects of the UHI and how it can be mitigated. Through different strategies implemented by governing bodies of cities are the strategies which aim to reduce the solar gain by the built environment through different techniques. One of these strategies is to reduce the solar radiation gain by these areas and focuses on increasing green spaces in the cities through parks, roofs, streets and etc.. This study reviews two successful example of these cities - London and New York City- to extract the underlying strategies that are implemented by these cities' governing bodies. Results shows microclimates offered by parks (green spaces), plants and vegetation play a significant role in achieving this goal and on the other turning the surfaces albedo to a higher level through making them brighter can be two successful strategy in reducing the Urban Heat Islands.

**Keywords:** Urban heat Island, Mitigation, Green Spaces, New York, London

## INTRODUCTION

Rapid Developments of cities and its industrialization leaded toward the discovery of a new phenomenon named Urban Heat Island in 1810s by Luke Howard however the term was not quiet tangible at that time(Howard, 1818). Urban Heat Island –officially abbreviated as UHI- is a phenomenon that occurs due to human activities and above all, land surfaces modification in which metropolitan areas created by humans happen to be warmer than its surroundings. This phenomenon is more tangible during night since the temperature gap between urban area and its surrounding is a more significant number and can be explicitly sensed while winds are weak in the area and also the phenomenon is more often discerned during winter and summer and as a result affect thermal comfort of occupants (which is mostly studied through earlier local studies for instance a study named Evaluation of thermal comfort in urban areas (Heidari and Azizi, 2017). Some studies including a study on London, New York and etc. has developed strategies to mitigate UHI temperature(Li and Zhao, 2012) (Omar, 2012) (Solecki, *et al.,* 2005) (Taslima, *et al.,* 2015). The main aim of this study is to review current

*Corresponding Author Email: Farzamfarzam2010@Gmail.com
Tell: +989353741192 Fax: +982188427979

studies on how the Urban Heat Islands (the UHI) are formed and to review what mitigation strategies 2 major cities took on and developed.

## Material and methods

This is a narrative-descriptive review(Clandinin, 2006) -which has been used by other studies to review the terminology and studies of different cities as an report (Garner and Scott, 2013) (Moulaii, *et al.,* 2017) (Moulaii, *et al.,* 2016)- of UHI formation and strategies which had been implemented in New York City, London using following inclusion criteria:

Both cities implemented strategies and further has been investigated by studies on use of vegetation, trees, green spaces and albedo increase effects, and studied urban fabrics and facades.

This study first reviews on what the UHI is and later discusses what the mechanisms in mitigating the UHI are by using green spaces, evaporation and shading and reflectance mechanism, how the wind is playing a significant role in mitigating the UHI

## Urban Heat Island

Concerns regarding Urban Heat Island grew because of assumption of its effect on global climate change, some studies proposed UHI is in direct contact with Global warming whereas the others rejected and proposed no such an impact exist on global temperature. (Huang and Lu, 2015) some studies including the study of Xiamen city confirm the occurrence of the UHI and the city factors are enumerated as Human Manipulation of land including replacing vegetation coverage with synthesized constructional materials such as asphalts and etc. and since these materials are mostly black, their energy absorption values are high and store the solar energy resulting in warmer areas than its surroundings which are covered with vegetation (Han-qiu and Ben-qing, 2004).

### *Mechanism of Green Spaces in Mitigating the UHI*

First the air within the area of the green spaces need to be cooled down and then the cooled air shall penetrate the surrounding urban environment and since the temperature of this air is cooler than of what exist in the urban built environment, overall mitigation of the UHI can be achieved(Upmanis and Chen, 1999). (Yu, Hien, 2006)

This issue should be noted that the vegetation within the green spaces contain different mechanisms to cool down the air which is later circulated through urban areas, these mechanisms varying in their nature are as follow Fig. 1 (Jansson, *et al.,* 2007)

1. Evaporative Cooling
2. Shading and Reflectance
3. Time which the air is resided within the green space.

### *Mechanism of Evaporation:*

This mechanism (also evapotranspiration) tries to use solar energy as a mean to heat up the water and hence transforming it into vapor instead of using this energy to make the urban facades and fabrics warmer(Upmanis and Chen, 1999).

### *Mechanism of Shading and Reflectance*

As the name explicitly offers this mechanism obstruct the solar gain by urban facades and fabrics, it is important to pay heed to reflectance provided by trees as well(Upmanis and Chen, 1999).

### *Factors Which Affect the Mitigation of the UHI*

Factors influencing the mechanism of Green Spaces in mitigating the UHI includes Fig. 2 (Jansson, *et al.,* 2007)(Upmanis, Chen, 1999)

1. Extent of Area that cools down the air
2. Wind Strength
3. Wind Direction
4. Sky-View Factor
5. Continuity of buildings and its size of open areas along them

### *Mechanism of wind and its relation to urban environment*

Wind in green spaces plays a significant role in decreasing the UHI and as a matter of fact enabling the green space air to cool down the surrounding environment. Effect of Wind within the green space is divided into two different effects, one positive and the other intervene the process of heat reduction in urban areas(Jansson, *et al.,* 2007).(Upmanis, Chen, 1999)

In the wind speeds which are light results in since the wind passing through green spaces is low, the process differs from what the high speed wind causes to happen, in this case warm air in urban areas and surrounding built environment ascends and hence the cooler air of green spaces penetrates through built environment and makes the urban area cooler(Jansson

*et al.,* 2007)(Upmanis, Chen, 1999).
The UHI and heat waves have the tendency to be formed in a condition that circulation of air is obstructed and an air mass forms in the area which is heated and hence causing the UHI to occur(Wilby, 2003).

### *LAI (sp): Leaf Area Index*

LAI (sp): Leaf Area Index: this index is developed as combined density of tree age and planting density for studies on impact of vegetation cooling effect relative to the size of the vegetated area(Upmanis, Chen, 1999).

### *Reporting the UHI*

In most studies the UHI is reported based on location, weather, time of day and season accordingly, resulting in quantifying the UHI mainly based on hourly mean(Authority, 2006) (Han-qiu and Benqing, 2004) (Kolokotroni, *et al.,* 2006) (Rosenzweig, *et al.,* 2006).

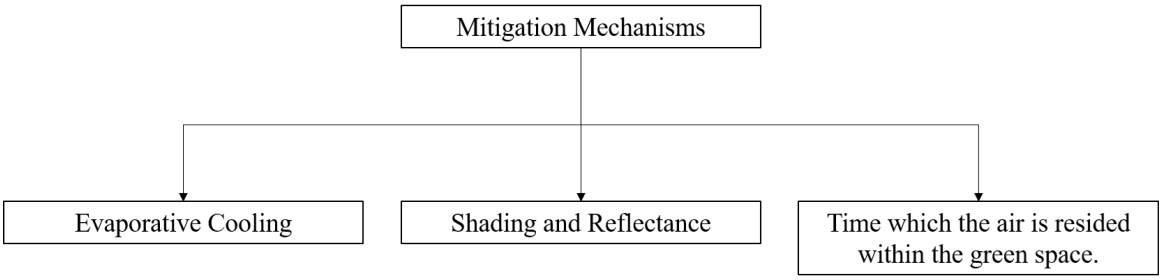


Fig.1:Mitigation Mechanism

## Study of London

This study focuses on Kensington Gardens of London with an area of 111 ha. In west of Hyde park with two large water reservoir, trees, grass and etc. This study uses a survey method and monitors the temperature. This study results in reports on air temperature, local mitigation of the UHI:

### *Air Temprature and the UHI*

Air temperature was recorded from August to December 2011 in which air temperature demonstrated a biophysics pattern in day and night. The air temperature in the city is influenced by the synoptic weather conditions, Local Scale Climate and Extraneous microclimate(Jansson, *et al.,* 2007).
This study shows the UHI of London is more of a nocturnal phenomenon continuing on the significance of the UHI of London since it may exceed 10 degrees and hence influencing the thermal comfort of its residents. Strategies implemented in urban climate adoption includes increasing green areas of a city. This study results demonstrates impact of green spaces on cooling the surrounding environment and abating the UHI of that particular area however extent of this effect shows a direct relation to green spaces area(Jansson, *et al.,* 2007).
This study recommends the importance of evaluation periods including evaluation is recommended to be over a number of days, weather conditions and ambient temperature to result in accurate cross-study on green spaces cooling effect(Doick, *et al.,* 2014)

### *Buffer Zone*

"Buffer zones", known as the boundary in which the cooling process effect commences was reported by a study which observed a buffer zone on outer layer of a green area boundary(Shashua-Bar and Hoffman, 2000). But in London study such an issue was not reported due to the extent of the study of 70m distance and sensors used. To determine these buffer zones one must use high frequency sensors starting from 10-20 m from boundaries and continues to over 100m of distance(Doick, *et al.,* 2014).

### *average drop rate of cooling effect*

The article demonstrates that average drop rate of cooling effect is 1.4%/m however the former

study demonstrated it as 2.3%. it should be noted that this gap around 1% is due to the size of green spaces(Doick, *et al.,* 2014).

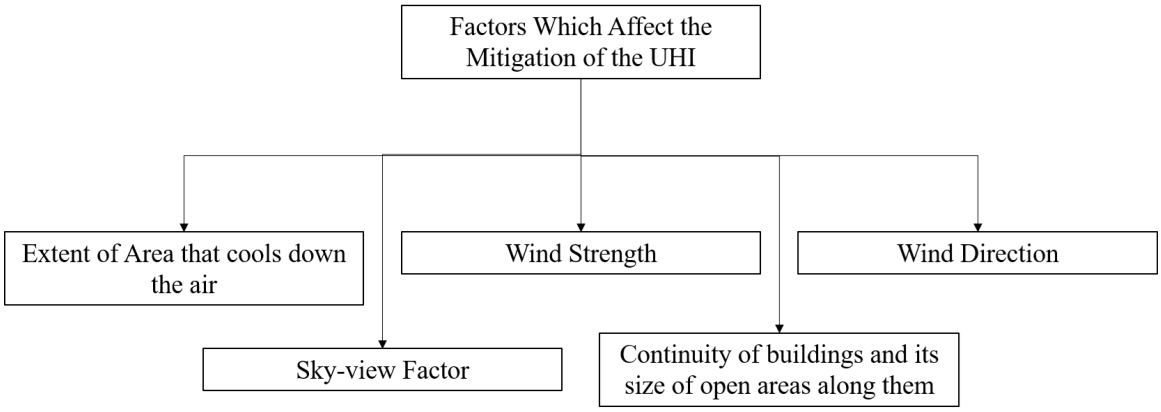


Fig. 2:Factors which affect the mitigation of the UHI

*The Rule of Thumb*

A rule of thumb: it has been hypothesized by a study that cooling boundary is equivalent of approximately the width of the green spaces(Upmanis and Chen, 1999). The study of London rejects this rule of thumb.

## Study of New York

Primary finding of this study might play a significant role for further implication of strategies in city scale. This study found increase of vegetation and plants in a city is more effective than increase of albedo in urban roofs, facades and fabrics and among all the vegetation and plants, curb side planting is the most effective one that can result in the UHI mitigation. But also in this study it is demonstrated that the most significant reduction of temperature is possible to achieve through implementing light surfaces on the city façade and fabrics but it should be noted that this latter finding is because of fabrics and façade that can be redeveloped in the city than the area which can be vegetated. This limitation in planting and creating vegetation might be considered through further development of strategies. Recent finding area that can be developed is about 64 of New York City fabric and façade area. (Rosenzweig, *et al.,* 2006)

Living roofs as the second option can be considered however the effect of this option is lower than curb side planting resulting in less cooling per unit area. In considering to implement this strategy, it should be noted that trees and plants on the roofs can not cast shadow on sides of surrounding buildings and hence its effectiveness is lower(Rosenzweig, *et al.,* 2006).

*The New Yorker Strategist*

New York City strategist offer 6 strategies to be implemented in the cities to reduce the UHI, first is the urban forestry which can be synthesized or can be the development of current forestry which is present in the area and the mitigation scenario of this case includes three types Fig. 3(Rosenzweig, *et al.,* 2006)

*Urban Forestry:*

First is developing urban forestry through planting grasses in the areas that trees are present as discussed in this article through vegetation a appropriate reduction of the UHI is possible and tangible. Planting grass in these areas is called open space planting(Rosenzweig, *et al.,* 2006).

Second is redeveloping the street with urban forestry this means planting trees and turning streets to streets that include trees. This strategy is called curb side planting and same as the former results in reduction of the UHI due to increasing vegetation(Rosenzweig, *et al.,* 2006).

Third combining these two recent strategies into one and planting grass and coincidence turning

present streets to have trees on them and hence resulting in a greater effectiveness that the individual strategies(Rosenzweig, *et al.,* 2006).

*Light Surfaces:*

Light surface can affect the UHI in two ways which both are effective,:

First is increasing the albedo of roof tops which can reflect the solar radiations resulting in decrease in the UHI by reflection(Rosenzweig, *et al.,* 2006).

Second is sides and other surfaces increase of albedo which can result in the same effect as above(Rosenzweig, *et al.,* 2006).

*Living roofs*

This type is those roofs with vegetation in cases can include trees and in some other a simple layer of vegetation such as grass can be implemented(Rosenzweig, *et al.,* 2006).

*Ecological Infrastructure*

Ecological infrastructure is the term used for the combination of green spaces including the use of grass and increasing trees on the streets (curb side planting) and transforming roofs to living roofs meaning adding vegetation to the top layers (Jansson , *et al.,* 2007).

*Urban Forestry and Light Roofs*

This strategy is also using the former strategy including using the grass in different conditions and increasing trees on the streets but only differs in the third part and replaces the living roofs with light roofs(Rosenzweig, *et al.,* 2006).

*Combination of All*

This type is a combination of all above strategies including 50% of use of space and adding 50% curb side enforcing the living roofs by 25% and 25% use of light roofs(Rosenzweig, *et al.,* 2006).

## Conclusion

This study reviewed general terminology of the UHI (Urban Heat Island) and its mechanisms including evaporation, Shading and Reflectance, Time which the air is resided within the green space and continued on green spaces and its influence on the UHI and introduced and discussed the factor which influence their mechanisms including Extent of Area that cools down the air, Wind Strength, Wind Direction, Sky-View Factor and Continuity of buildings and its size of open areas along them. Further on the article strategies from New York is reviewed and role of parks (green spaces) in London is introduced using the study on London. To conclude 6 strategies from New York strategists is offered on how to mitigate the UHI using green spaces and light surfaces.

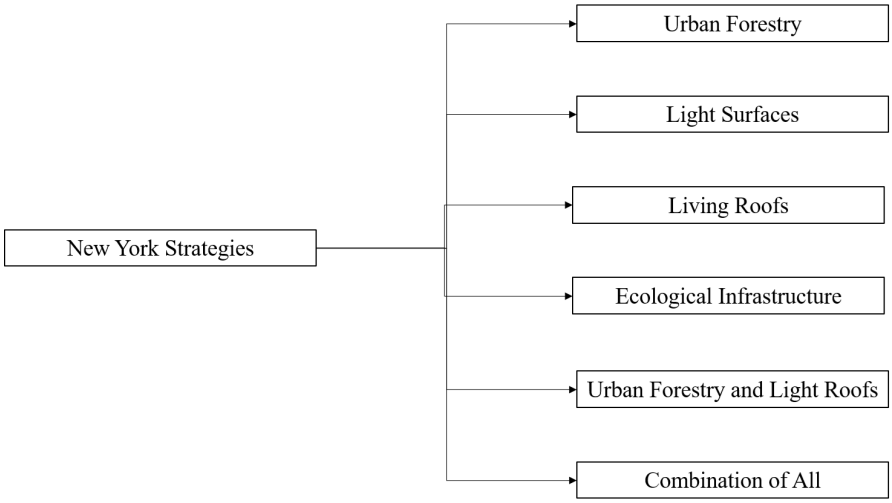


Fig. 3:New York Strategists

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