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# THE STUDY OF CHANGING THE COLORS OF BUILDINGS IN HOT ENVIRONMENTS TO REDUCE THE EFFECT OF (UHI)

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## ABSTRACT

Urbanization is currently the main and most important cause of climate change. As it causes more environmental problems such as global warming and air pollution. In urban areas, heat islands result from heat retained by large and complex urban buildings and then radiated back, as well as anthropogenic heat generated by various other sources such as vehicles and factories. Therefore, the heat island phenomenon, has been researched in depth using many scientific techniques, to counter extreme changes so that buildings and open spaces respond appropriately to the climate.

**KEYWORDS:** Urban Heat Islands, Remote Sensing Analysis, Land Images, Geospatial Data Analysis, Vegetation Index, Land Use and Land Cover Changes

## دراسة تغيير الوان المباني بمناطق البيئات الحارة للحد من تأثير الجزر الحرارية الحضرية

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## الملخص

يعد التحضر حاليًا السبب الرئيسي والأهم لتغير المناخ. حيث يتسبب في المزيد من المشكلات البيئية مثل الاحتباس الحراري وتلوث الهواء . في المناطق الحضرية ، تنجم الجزر الحرارية عن الحرارة التي تحتفظ بها المباني الحضرية الكبيرة والمعقدة ثم تشعها مرة أخرى ، فضلاً عن الحرارة البشرية المنشأ الناتجة عن مصادر أخرى مختلفة مثل المركبات والمصانع. لذلك ، فإن ظاهرة الجزر الحرارية ، تم بحثها بعمق باستخدام العديد من التقنيات العلمية ، لمواجهة التغيرات المتطرفة حتى تستجيب المباني والمساحات المفتوحة بشكل مناسب للمناخ

**الكلمات المفتاحية : جزر الحرارة الحضرية ، تحليل الاستشعار عن بعد ، صور الأرض ، تحليل البيانات الجغرافية المكانية ، مؤشر الغطاء النباتي ، تغيرات استخدام الأراضي والغطاء الأرضي**

## 1 INTRODUCTION

Urbanization and changes of land covers have a notable power on the climate change such as the problem of urban heat islands. The urban heat island (UHI) effect refers to the temperature rise of any man-made area. This effect is mainly caused due to the concentration of human activities and artificial built surfaces which are mainly composed by construction materials that efficiently absorb and store solar energy, releasing heat slowly, and mainly during the night. The urban heat island effect is a critical factor for air quality management, environmental studies and public health in urbanized areas.

## 2 AIM OF THE PAPER

This paper aims to concerned with clarifying the phenomenon of urban heat islands, its causes, problems, and methods of measurement. It sets some policies and strategies that may contribute to mitigating its effects on the urban and environmental aspects by studying some experiences and experimenting with tools to measure and evaluate this phenomenon.

## 3 METHODOLOGY SCENARIO

The paper relies on the quantitative approach in collecting and analyzing data, with a focus on observations and statistics. By collecting data on the causes and factors of UHI including tools that measure UHI. Subsequently, an extensive literature review was conducted on a lot of research involved in the study and analysis of appropriate mitigation methods and strategies, and their effects on universal health coverage with their various efficacy quotas.

## 4 URBAN HEAT ISLAND: ABSTRACT DEFINITION, CAUSES AND FACTORS

The UHI phenomenon expresses the difference in mean temperature between urban and rural areas. Increased natural warming of surfaces and the environment within cities relative to their outer perimeter is indicated by UHI, especially at nighttime. The urban form of cities, with a hard surface and arid nature, which makes them much hotter than their surroundings, contributes to the UHI located in urban areas. All local considerations about the formation of the urban context must be considered in order to understand and analyze more clearly the presence of this phenomenon, its intensity, and its effects, as well as studying the characteristics of the formation of cities. To analyze the effect of urban morphogenesis on UHI and to determine the relationship between various phenomena and urban formation, researchers study differences in morphological patterns of urban areas and their association with UHI intensity at the local scale.

In this study the effect of land cover change on surface temperature was investigated. and link UHI patterns to changes in vegetation, land cover, land use, and areas under construction.

The researchers divided Earth's surfaces into seven major categories, including natural and man-made environments. Water bodies have the lowest LST and UHI intensity, followed by green areas, while industrial areas have the highest UHI and LST intensity because they produce more heat than man-made ones.

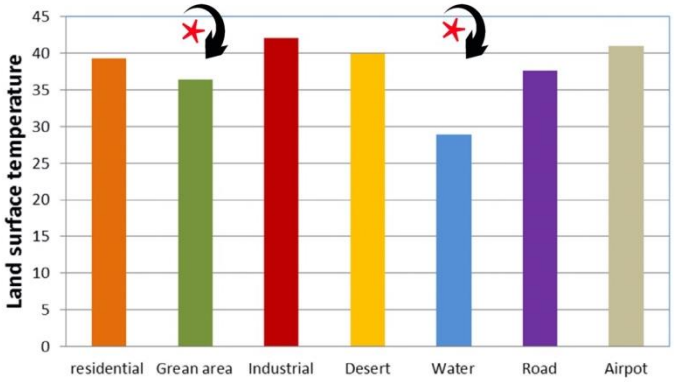


**FIG. 1:** LST & UHI mean graph for various land uses.

## 5 UHI MEASURING TOOLS AND CONDUCTION METHODS

- Field measurements as well as measurements approved by meteorological stations
- Surface temperature can be determined by airborne remote sensors or satellite results, which can be used throughout the year and even at specific periods.
- Analysis of the geospatial database and the use of Geographic Information System (GIS).

## 6 MITIGATION TACTICS AND STRATEGIES CONSIDERING URBAN MORPHOLOGY, URBAN GEOMETRY & URBAN MATERIALS

### 6.1. Urban Morphology

Among the most important elements of urban formation are green areas, buildings of all kinds, urban materials and infrastructure. Urban morphology, which is concerned with the masses, orientation and spaces between buildings in the city, also contributes to the formation of UHI. Where large buildings and streets with narrow widths can limit the process of good ventilation by creating grooves in which the high heat resulting from human activities and solar radiation collects. In fact, the SVF effect reduces losses in net radiation produced by buildings and roads. Moreover, urban morphology affects vehicular traffic and paths thus increasing inputs to gain more heat.

In this study, we can present the most important urban characteristics that may describe the urban formation of any selected work areas; Then these characteristics are analyzed and their reflection on any study area to obtain an accurate and effective description before completing the measurements and the distributed results are as follows: building heights and spacing between them, urban shadows, ratio of dimensions of streets and voids, road widths and coverage ratios (vehicle density), as well as landscape The sky, green spaces and plants, building proportions (building density) and the whiteness factor of the sidewalks, the horizontal surfaces of the lands and the vertical surfaces of the facades.

Also, the spatial location of the selected areas is a very important factor that should be taken into account, because it has an effect on the suburban areas close to the desert areas such as the study area, but it appears to have less effect than the UHI.

As a result of the above, this shows that urban morphology, which has a great influence on the phenomenon of UHI, is the primary factor governing UHI, and not the location of the urban area as it was known before.

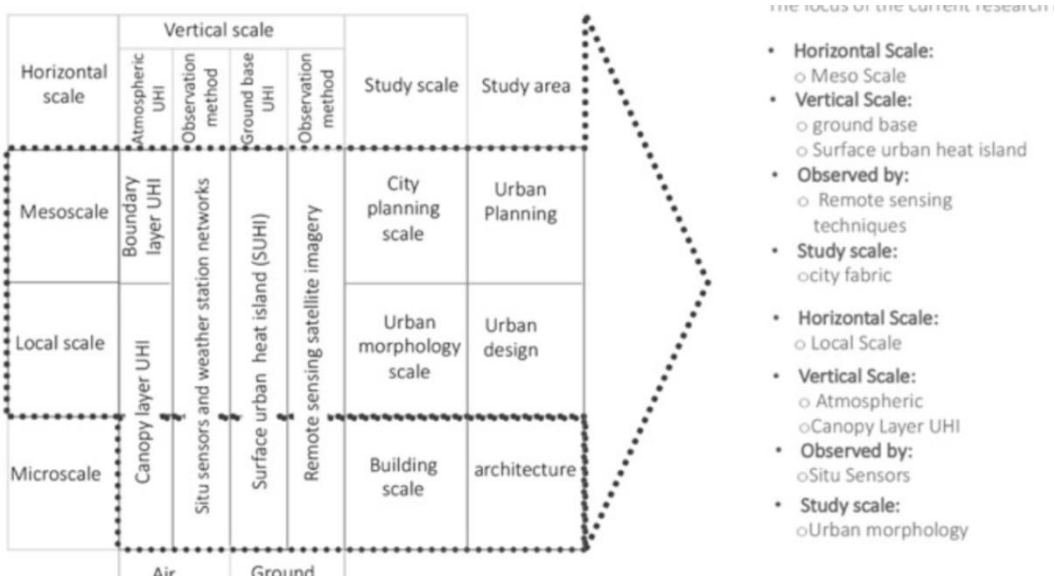


**FIG 2.** Urban Heat Island study scale and techniques.

## 6.2. Urban Materials

Through the study, it was found that urban areas have less reflection of the sun, higher absorption of solar radiation, and those areas have greater heat capacity than rural areas due to their less vegetation and darker surfaces. In their report, Wanphen and Nagano discovered that there is a temperature difference in urban areas from the surrounding (rural) areas that can reach 5-15 °C. (Depending on the size of the urban area) It has also been shown that man-made heat (such as heat generated by vehicles), the albedo factor, roads, sidewalks, and even land cover materials, all of these elements have a significant impact on increasing the temperature.

### 6.2.1. Building materials

Through the study, it was found that general strategies can be developed to mitigate the effects of UHI through urban materials on both the macro and medium scales of the urban space.

To achieve better results, these mitigation strategies can be developed on a small or medium scale of urban space and can be done through building materials as well.

Skin building engineering has the potential to reduce the air temperature and UHI intensity to the maximum extent by using the ideas of thermal conductivity and finite temperature step and working on the data of infrared emission variables.

Also, building materials must be taken into account, starting from the construction stages of the building structure to the interior finishing materials, as well as the facades' finishes and colors, which are the focus of this study.

Moreover, vertical green areas are divided into two types: living walls and green facades. Finally, it should be noted that the green façade mentioned here is a type of green vertical roof in which some metal frames and square-shaped panels are attached to the wall of the building and then serve as an anchor for creeping or climbing plants such as grapes, ivy, and others.

It is worth noting that albedo is another important factor that must be considered within the study of urban materials, as the rate of whiteness is determined by a number of surfaces, materials, and color through multiple measurements.

Through the study, it was found that materials with light colors contain a higher whiteness coefficient and absorb less energy than the same materials if they were colored with dark colors.
Dark colored materials absorb more heat during the day and reflect more light at night increasing the temperature of the urban landscape. Changing the color of surfaces and increasing the whiteness of its color by (0.25 to 0.40), which leads to a decrease in air temperatures by up to 4 degrees Celsius.
In addition, it was found that coloring surfaces with reflective colors will have a significant impact on LST & ST by influencing the heat it absorbs, stores and emits throughout the day. It was also discovered that painting with cold colors such as blue (0.65 SAR) can reduce the temperature (1.2-3.7 °C). This is what was studied in the selected work area.
Finally, good thermal insulation of the building materials used is an excellent way to reduce UHI and ST intensity. It was also shown that all UHI mitigation inputs, such as economy, time and many other factors, must be taken into consideration. For example, the use of a double-skin façade may be costly and heavy, while the use of green façades may change the appearance of the façade, but the use of vegetation may take a long time before the tree gives the proper shading, affecting for a long-time aspect of the design of the building.
An ideal thermal insulator should be found to mitigate the effects of UHI, and we should first consider other factors such as heat resistance and heat re-emission. Thermal conductivity, thermal diffusivity, density, specific heat capacity, albedo, and emissivity are important factors to consider in the design and post-design phase.

The specific heat capacity of a substance is the amount of heat required to raise the temperature of 1 kg of a substance by 1 Kelvin (or 1 degree Celsius). Since it takes longer for more heat to be absorbed before it heats up (temperature rises) due to the heat transfer process, a good insulator has a higher heat capacity. In the study of heat re-emission, the main factors are the albedo factor and the rate of heat emission. The greater the whiteness, and choosing the appropriate colors, the temperature will decrease, because heat emission is an important factor in re-emission of heat. By the ability of the surface to issue an IRE. Also, urban roofs with a high emission rate will emit more heat, and through the study it was found that those areas will become less cold when using white colors, as building materials lose many heat emissions by coloring them with appropriate colors.

### 6.2.2. Pavement materials:

Through the study, the thermal balance of the paving should be determined and the appropriate materials for paving should be selected and painted in whiter colors, as it was found that through the amount of solar radiation absorbed and stored by the paving material, the amount of infrared radiation emitted from the pavements, and that heat transferred through the mass of the material, and it was shown By measuring the temperature on those areas, differences are shown to study the solar reflection to be lower with temperatures that may reach 12 degrees Celsius (between the sample of the thin asphalt layer of light white color and the traditional black alternative).

### 6.2.3. Land covers materials

It is very important to study green spaces and plant types in urban areas, as we discovered that the combined effects of shading provided by trees and buildings may lead to a significant drop in temperature in urban areas, resulting in what is known as cold islands within urban areas.
By applying this, it was found that the difference in air temperature between the city and the green areas or shaded areas may reach 4 degrees Celsius. Moreover, another study was done by increasing the green areas and showing that the use of plants and agriculture can only reduce the air temperature by 1.3 - 1.6°C. The results of the study also indicated that the vegetation cover had

a significant impact on the city's climate and the formation of cold heat islands, thus reducing the temperature of urban areas.

### 6.3 Urban Geometry Role and Building Materials

Among the most important aspects and components of urban engineering: geometric shape, urban density, orientation, and valley (H / W). All this influences wind speed and temperature reduction in the urban community: the H/W ratio and density provide orientation relative to the sun providing sufficient shading for buildings in the area, ultimately reducing heat gain and thus reducing the temperature and climate of the urban area.

The accumulation and composition of buildings with a certain shape, the provision of open spaces, the formation of roads that make urban canyons and urban engineering.

It is known that cities have different engineering features, such as differences in the patterns of road networks, the shape of building distribution, and green spaces, which contribute to the volume of urban density. The vertical materials of the urban area cover thus have a clear influence on the local climate, especially in high-density vertical urban areas.

The continuation of the use of Softscape materials in the green spaces. We confirm that the solar radiation gain rate and wind effects are affected by urban engineering factors. On the other hand, physical elements affect the absorption of solar radiation and the degree of reflectance. This coupling factor has the greatest influence on the temperature intensity in urban areas. Geometric factors can be categorized into urban canopy, SVF, roofs, orientation of buildings and roads, floor area ratio (FAR), occupied density, urban valley ratio (H/W), building height, and building coverage ratio (BCR). For physical factors (horizontal and vertical materials): vegetation/tree, roof, sidewalk, park, heat storage, facade, emissivity, and colorant/paint (whiteness).

## 7 THE EFFECT OF CHANGING THE COLORS OF BUILDINGS

As mentioned earlier, heat islands directly affect climate change and increase temperatures in urban areas. The city of Chefchaouen in the Kingdom of Morocco, a city of a desert nature with a dry climate, most of its houses were built after the year 1470 AD on mountainous areas located at an altitude of 560 meters, and the purpose of its establishment was to be a defensive city to repel the Portuguese attack. Currently, the city of Chefchaouen is called the Blue City, as the city's buildings are dominated by white and blue colors, which reduces the temperature and climate of the city. It was noted that the temperature improved after the city's houses became blue and white Figure (3) represents city temperatures. Figure (4) also represents the color ratios of some of the buildings that were studied. Figure (5) represents the temperatures of the buildings if they are painted with the same colors and the same proportions.

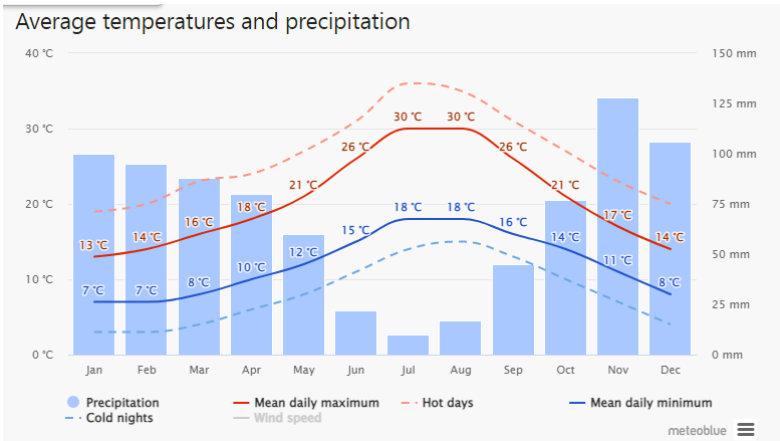


**FIG 3.** Average temperatures and precipitation

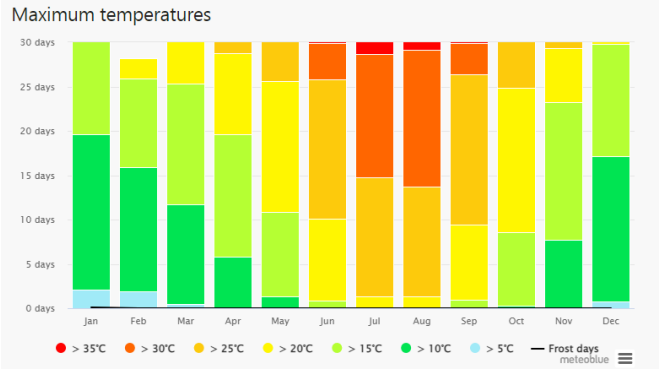


**FIG 4.** Chefchaouen Maximum temperatures

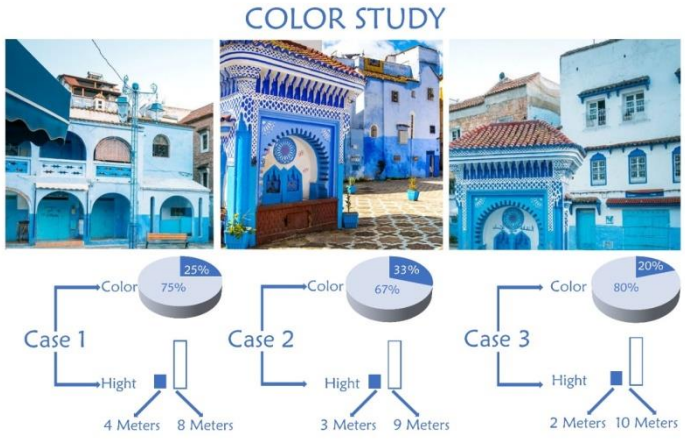


**FIG 5.** Study of colors in the city of Chefchaouen

It was noted that the color ratio is as follows:

- Blue to white color ranging from 20:35%.
- The internal temperature has been reduced to about 5℃.
- The color change contributed to a feeling of comfort and happiness.

## SUMMARY AND CONCLUSION

1) Different urban patterns contribute significantly to the effects of UHI. And the city's climate change. The role of this phenomenon is evident in the presence of hot spots in the context of the city. So far, many methods and techniques have not been used to analyze UHI, and therefore it is not recommended to rely on only one method to address these effects.
2) The research conducted indicates that UHI mitigation technology can be classified into three sections, including urban formation, engineering and material variants. This was discovered through a series of experiments reviewing urban heat island mitigation. These three technologies work together to lower UHI in urban areas and reduce city temperature.
3) Urban morphology is the most influencing factor for UHI. However, the characteristics of urban morphology. Including the use of urban materials, is one of the most important factors affecting the presence of UHIs in cities. Including building heights, distances between buildings, urban canopy, skyline factor, road width as well as vehicle density, percentage of green coverage in addition to the location and surroundings of the urban area.
4) With reference to urban materials some criteria should be made; Albedo agent, reflective coatings, thermal insulation (for facades, roofs), landscaping and vegetation (where porous plantings should not be replaced with non-porous materials, which will restrict or mitigate evaporative cooling), paving materials, building roofing materials and green roofs.
5) Studying the consequences of urban heat islands is not the primary goal; Rather, the ultimate goal is to eliminate or mitigate them. Therefore, it is critical that future research focus on the importance of understanding and predicting urban heat island process simulation, environmental impacts, and mitigation strategies.
6) The study of color should be included in the studies concerned with climatic effects, as the change of colors in the facades contributed to reducing the temperatures in the city and thus contributed to reducing the effect of urban heat islands in the city.

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