T.C.
ISTANBUL GEDİK UNIVERSITY
INSTITUTE OF GRADUATE STUDIES

ADMINISTRATIVE PLANNING FOR THE EFFECT OF VEGETATION COVER AND PAVING MATERIALS ON IMPROVING PEDESTRIAN THERMAL COMFORT FOR STRATEGIC STREET IN BAGHDAD CITY

MASTER'S THESIS

Mohammad Jaber THEEBAN AL-TARAQANY

Engineering Management Department

Engineering Management Master in English Program

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Thesis Supervisor: Assoc. Prof. Dr. Redvan GHASEMLOUNIA

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T.C.
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Enstitümüz, Engineering Management Department İngilizce Tezli Yüksek Lisans Programı (201281024) numaralı öğrencisi Mohammad Jaber THEEBAN AL-TARAQANY'nin "Administrative Planning for the Effect of Vegetation Cover and Paving Materials on Improving Pedestrian Thermal Comfort for Strategic Street in Baghdad City" adlı tez çalışması Enstitümüz Yönetim Kurulunun 09/01/2023 tarihinde oluşturulan jüri tarafından *Oy Birliği* ile Yüksek Lisans tezi olarak *Kabul* edilmiştir.

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DECLARATION

I, Mohammad Jaber THEEBAN AL-TARAQANY, hereby certify that this thesis entitled " Administrative Planning for the Effect of Vegetation Cover and Paving Materials on Improving Pedestrian Thermal Comfort for Strategic Street in Baghdad City" is my original thesis for the award of Master's Degree in Engineering Management at the Faculty of Engineering Management. I further certify that this thesis or any part thereof has not been submitted and presented for any other degree or research thesis at any other university or institution.

Mohammad Jaber THEEBAN AL-TARAQANY

PREFACE

To the person who gave me strength and pride... my dear father.

To the person who gave me love, tenderness, and loyalty .... my dear mother.

To my bond, my consolation, my joy, and my honor... my dear brothers.

To the symbol of faith, loyalty, and giving.... my life partner.

To the joy of my life who endured my travels and my absence .... my young children.

To those who have endured the hardness of studying with me during the Covid-19 pandemic... my colleagues.

To my inspirational supervisor Dr. Redvan, I dedicate to you my scientific research in Engineering Management Projects.

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ABBREVIATIONS

PMV	**:** Predicted Mean Vote
QA	**:** Quality Assurance
SR	**:** Solar Reflectance
SVF	**:** Sky View Factor
TE	**:** Thermal Emittance
UCI	**:** Urban Cool Island
UCI	**:** Urban Cool Valley

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ADMINISTRATIVE PLANNING FOR THE EFFECT OF VEGETATION COVER AND PAVING MATERIALS ON IMPROVING PEDESTRIAN THERMAL COMFORT FOR STRATEGIC STREET IN BAGHDAD CITY

ABSTRACT

This research focuses on studying the effect of the type of materials used in floors on the surrounding environment temperature and knowing the effect of shading on its thermal performance in open areas located in a hot and dry climate. An applied study of Al-Rubie Street in Baghdad was conducted during the summer of year 2010 as a case study.

The study included taking readings of the thermal performance of a number of open spaces and pedestrian paths inside the street, and the readings were monitored on different types of floor finishes to measure the air temperature by means of temperature and humidity sensors, and then analyzed by the computer. The results of the study showed a clear effect of the types of materials used in the flooring on performance and also showed that the shade has an effective effect on improving the thermal performance of open spaces. The results proved that areas shaded by natural elements such as trees are closest to the level of thermal comfort and that the pedestrian paths protected from direct sunlight contribute to increased evaporation, which is one of the important criteria for indirect cooling used in environmental design. The study also concluded the importance of staying away from heat sources such as the movement of cars and the selection of finishing materials and the importance of applying environmental design standards in defining pedestrian paths, which positively affects the thermal performance of the environment surrounding the space. Thus, the range of thermal comfort for the users of the place can be approached.

Keywords: *City planning, Urbanism, Baghdad*

BAĞDAT ŞEHİR CADDESİ İÇİN STRATEJİK BİTKİ KAPLAMASI VE DÖŞEME MALZEMELERİNİN YAYALAR İÇİN ISIL KONFORUNUN İYİLEŞTİRİLMESİNE ETKİSİNE YÖNELİK İDARİ PLANLAMA

ÖZET

Bu araştırma, zeminlerde kullanılan malzeme türlerinin çevredeki ortam sıcaklığı üzerindeki etkisini incelemeye ve sıcak ve kuru bir iklimde bulunan açık alanlarda gölgelemenin termal performansı üzerindeki etkisini öğrenmeye odaklanmaktadır. Bağdat'taki Al-Rubie Caddesi'nin uygulamalı bir çalışması, 2010 yılı yazında bir vaka çalışması olarak gerçekleştirilmiştir.

Çalışma, cadde içindeki bir dizi açık alan ve yaya yolunun termal performansına ilişkin okumaların alınmasını içeriyordu ve okumalar, sıcaklık ve nem sensörleri aracılığıyla hava sıcaklığını ölçmek için farklı zemin kaplamalarında izlendi ve ardından bilgisayar. Çalışmanın sonuçları, döşemede kullanılan malzeme türlerinin performans üzerinde net bir etkisi olduğunu ve ayrıca gölgenin açık alanların termal performansını iyileştirmede etkili bir etkiye sahip olduğunu göstermiştir. Sonuçlar, ağaçlar gibi doğal elemanların gölgelediği alanların termal konfor düzeyine en yakın olduğunu ve doğrudan güneş ışığından korunan yaya yollarının çevre tasarımında kullanılan dolaylı soğutma için önemli kriterlerden biri olan buharlaşmanın artmasına katkıda bulunduğunu kanıtlamıştır. Çalışma ayrıca, arabaların hareketi ve kaplama malzemelerinin seçimi gibi ısı kaynaklarından uzak durmanın önemi ve mekanı çevreleyen ortamın ısıl performansını olumlu yönde etkileyen yaya yollarının tanımlanmasında çevresel tasarım standartlarının uygulanmasının önemi sonucuna varmıştır. Böylece mekan kullanıcıları için ısıl konfor aralığına yaklaşılabilmektedir.

Anahtar Kelimeler: *Şehir planlama, Şehircilik, Bağdat*

1. INTRODUCTION

1.1 General Context

The Urban Heat Island (UHI) phenomenon, which defines urban heating in comparison to its immediate surroundings, has received a lot of attention in urban climate research. Methods to reduce the Urban Heat Island are an essential aim in urban construction and development, particularly in hot climate countries. UHI is Global warming is found to be linked because of its donation to greenhouse gas emissions effect, and thus in response to environmental heating, Many nations and localities have implemented mandated adaption measures. stratiote is to reduce the effects of the Urban Heat Island and the change in urban climate The interaction of the urban structure (building surface covering (built-up, asphalt, plant, soils, groundwater), urban fabric (constructed and natural fibers), and urban metabolic determine the change in urban climate (Humanity heats up, moisture, and pollution.). Climate change has a severe impact on natural and human systems in Arab regions; these regions have warm and dry weather (desert climate)). In scientific research, only modest efforts were made to improve pedestrians' outdoor thermal comfort. Increased urbanization has consequences such as decreased biodiversity, increased traffic, and increased demand for energy-intensive products. Because of higher levels of air pollution and hotter days, indoor cooling systems and urban heat islands have a direct impact on residents' well-being and health.

Arab nations have worked to alleviate the repercussions, but they face several hurdles in order to stay up. This effort aims to find factors that might improve walker pleasure in Baghdad.

1.2 Significance of the Study

The main challenge for the designer when designing a street from a climatic standpoint is the periodic distinction between inner and outward wants. In the summer, for example, sun protection is required, whereas solar access is required in the cold days this suggests simplicity as well as exposure towards the sky in theory.

As one of the aridest zones vulnerable Iraq confronts a distinct combination of ecological issues caused by global warming. Climate change has resulted in increased In the latest days, the number and severity of unusual weather occurrences have increased, as has environmental deterioration across the nation, with more regular and intense storms, floods, and exceptionally heateats. The study's significance lies in proposing an administrative system for the stages of modifications used to improve thermal sensitivity in hot and dry environments. And highlighting how to submit the proposals and modifications needed to improve the thermal comfort of one of Baghdad's most important main streets.

1.3 The thesis's Purpose

In this thesis , the researcher seek to better understand how several factors, such as paving materials for main streets, pedestrian path paving materials, the importance of adequate afforestation, and the role of shading in pedestrian paths, affect pedestrian comfort, particularly in Baghdad's main and important streets because it is one of the hot and dry cities, and because of the long summer period. The findings of this research would be presented in form of redesigns directed at improving UHI remedial actions and increasing walker comfort. Lastly, we consider potential approaches for dealing with outdoor thermal comfort issues in hot, dry climates. climates, especially on pedestrian sidewalks.

1.4 Methodology

Many aspects of urban microclimate models differ significantly, including The physical foundation, time and geographical precision, and data acquired are all important considerations. ENVI-met is a modeling tool for important atmospheres such as air movement, solar transports, temperatures, and moisture. ENVI-met fully models all environmental parameters influencing thermal comfort, including air temp, moisture content, air velocity, sunlight, and temperature (Ali-Toudert, 2005).

This program was selected because it can model three-dimensional structures and quantify the impact of plants on air temperature. To analyze outdoor thermal comfort and average radiant temperature at the street level, we utilized PMV (Predicted Mean Vote) indices. Ideal air temp, moisture content, and wind velocity are also estimated to examine the influence of hot weather and dry weather on walker comfort.

1.5 The Structure of the Research

The dissertation is broken into five chapters. chapter one is the introduction of the thesis, The second chapter includes a quick summary of terminology and the most relevant studies concerning the occurrence of urban heat islands, as well as mitigating techniques, as well as an explanation of the effect of vegetation, paving materials, and the effect of shading. Also, chapter two contains more explanation of the effect of street design on urban canyons. The third chapter provides context for the simulation analysis of urban microclimates It is also concerned with the significance and features of ENVI-met. The numerical simulation results for the Baghdad study case are presented, analyzed, and discussed in detail in chapter four. The meaningful conclusions drawn from the simulation models are discussed in Chapter five. Furthermore, it includes recommendations and perspectives for future research.

2. LITERATURE REVIEW

2.1 Introduction

The study of urban climate is becoming extremely relevant because metropolitan regions see a substantially faster population increase than rural ones While cities housed just approximately 30% of the worldwide people in 1950, they currently host and over half of the worldwide people. In accordance with the Un System, urbanization will house over 66% of the worldwide people by 2050. (Simon.2016)

This urban growth not just to subjects additional individuals to the impacts of the urban microenvironment, but it also means that the already severe ecological difficulties in metropolitan areas will deteriorate. Effects of increased urbanization such as decreased biodiversity increased traffic, and increased power item consumption Because of increased rates of air pollutants and warmer days, interior cooling equipment and urban heat islands have such a powerful effect on inhabitants' well enough and wellness (Guneralp and Seto, 2008; Seto et al., 2011) High temperatures have been related in several research to greater cardiovascular issues and death. (Basu and Samet, 2002; Clarke, 1972; Vandentorren et al., 2004).

In addition to the outcomes of global change, that will increase the severity and length of lengthy rising temperatures, urban agglomerations will become even more vulnerable (Fujibe, 2011; Wilby, 2006). To address these concerns, urban development techniques today encompass not just economic, economic, and housing concerns, and also meso- and provide vital concerns to contend with the effects of climate change.in densely populated areas.

Climate change and rapid urbanization are factors to consider. In several countries and regions, as a result, mandatory adaptation strategies requiring vulnerability have been implemented. analyses and demand mitigation measures to mitigate the effects of urbanization heat islands, as well as to reduce air pollution.

2.2 The Effect of Vegetation

Green spaces have a significant impact on temperature reduction in cities due to their higher albedo in comparison to paving materials and evapotranspiration- the combined loss of water to the atmosphere through evaporation and transpiration. Trees are especially important for cooling through evapotranspiration and shading. Evapotranspiration can produce oases with 2-8 degrees Celsius colder air temps than their surroundings, as well as a cooling effect that extends out into the surrounding area. Urban vegetation or green infrastructure is critical not only to reduce urban heat islands and global warming but also to provide a habitat for many species and beauty, as well as improve the socio-environmental quality of life in cities.

The grass is the coolest of all surfaces tested, and researchers propose that grass surfaces be used as a standard to measure all so-called "cool pavements"* - materials with high solar reflectance to short wave radiation and low emissivity (the ability to radiate absorbed, or non-reflected solar energy). According to research, when light-colored surfaces are combined with the planting of new trees, significant energy gains are possible (Mitković1 et al., 2015)

The vegetation in urban parks provides a significant amount of shadowed spaces created by canopy shadowing, altering the mechanisms of heat transfer at floor level and thereby increasing the walker environment (Wang and Akbari, 2016; Yang et al., 2019; Zhang et al., 2021). A mature plant, according to De Abreu-Harbich et al., can lower the temp by 0.9 to 2.8 K between 10:00 a.m. and 2:00 p.m. in the summertime.

A plant's shadow creates vast darkened regions by collecting and preventing thermal radiation transfer of both the sunlight and the solid surfaces and impermeable surfaces, lowering temp. Field observations in Holland revealed that the mean radiant temperature was less beneath trees, with a small forest having a 7.4 K lower Tmrt. (Wang et al., 2015)

As stated by Monteiro et al., (2019) Sustainable construction, which consists of a system of urban trees and forests, personal and public landscapes (including campgrounds, lawns, open fields, plots of land, and greenways), eco-friendly rooftops, and natural vegetation areas relating to water carcasses (e.g., wetlands), offers significant advantages to urban society (UK National Ecosystem Assessment,

2014) One such benefit is a drop in local heat increases (Bowler et al., 2010), which can happen in a number of ways.

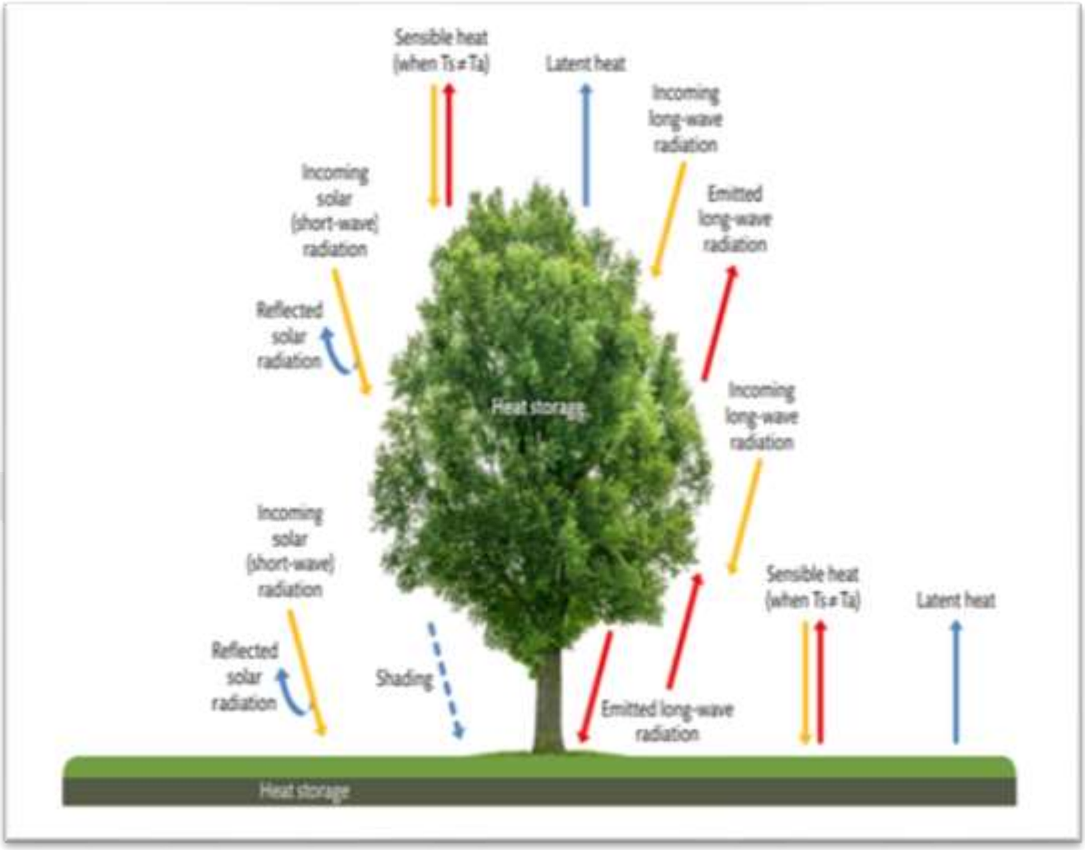

Figure 2.1: The Effect of Vegetation

Source: Monteiro et al., (2019)

2.2.1 Benefits of using vegetation

There are many benefits to utilizing trees and vegetation in the urban environment, besides mitigating urban heat islands (Monteiro et al., 2019).

- Trees and vegetation reduce By lowering energy consumption, we can reduce emissions of greenhouse gasses pollutants. They not only remove harmful pollutants, but they also absorb carbon sequestration nitrogen oxide.
- Reduced energy consumption: Trees directly shade buildings, reducing their air conditioning needs.
- Pavement maintenance can be reduced by tree shade: green shade can slow the deterioration of streets.
- Trees and vegetation improve the By offering aesthetic appeal, a home for numerous animals, and noise reduction, you may enhance your life's quality.

- The principal expenditures involved with establishing and keeping plants are the acquisition of supplies, planting, and continuing operations such as trimming, pest management, and watering.

2.3 How Green Infrastructure Reduces Urban Air Temperatures

2.3.1 Evapotranspiration process

Vegetation loses a portion of the heat they receive as moisture inside their leaves, which cools them. The vapors are subsequently evaporated into the air via the leaves' holes (stomata) without heating the surrounding air. Water may drain off the edges of foliage, pools of water, and ground. The overall mass of fluid evaporated is influenced not just by the usage of water for vaporization, but as well as features of the foliage and earth, the power production (from solar and lengthy irradiance), the ambient temperature, the relative humidity deficiency (the distinction in both the quantity of heat and moisture and the optimum level of moisture the air's capacity to hold at a particular temperature), and wind patterns.

2.3.2 Reflecting more solar radiation process

Natural vegetation regions, in general, reflect more solar energy away from the earth than black, synthetic turf. As a reason, less heat is absorbed, leading to warmer layers and reduced air temps in cultivated regions relative to nonareas that are accumulated.

2.3.3 Reduction of heat storage capacity and providing shade process

Natural vegetation regions have low thermal storage capabilities than many synthetic fibers and transmit energy to the air quickly due to their numerous tiny limbs and limbs that assist airflow. Extensive green regions, as opposed to constructed, non-vegetated places, will retain less warmth in the radiant energy in the day and unleash this to heat the air in the evening. Whenever trees, bushes, and some other plants connected to structures hide other urban objects against sunlight, they can lower the energy that is stored and released by those areas.

2.3.4 Providing a much more open view of the sky

Natural areas, such as playgrounds, parks, courtyards, and other limited areas, might have a greater percentage of open sky (higher sky view factor) than built-up regions.

This forwarding radiation dissipation and airflow, assists in the redistribution of sector participants**.**

2.4 The Role of Albedo

2.4.1 The use of albedo

Low-cost techniques that can assist to lower summer heat include the usage of high-albedo urban surfaces and the installation of urban plants.

Researchers propose that grass surfaces be used as a standard to measure all so-called "cool pavements" materials with high solar reflectance to short wave radiation and low emissivity (the ability to radiate absorbed, or non-reflected solar energy). Significant energy gains are possible, according to research, when light-colored surfaces are combined with the planting of new trees.

The usage of high-albedo urban structures and the installation of urban trees are two low-cost strategies that can assist lower summer heat. (Montario et al., 2015)

Several unfavorable environmental changes have resulted from industrialization. Landsat shifts and organic areas are displaced by urban fabric, which has greater heat than the neighboring country area, a phenomenon called as urban warming. The thermodynamic, photonic, and geometrical features of urban structures impact temperature rise and radiation, rresulting in the so-called Urban Heat Island (UHI) effect, according to a significant body of urban climatology. (Feyisa et al., 2014)

In large cities, two major phenomena have been observed in comparison to Their environments include a greater heat or specific heat capacity known as Urban Heat Island (UHI), as well as an occasional energy loss known as Urban Cool Island (UCI) or Urban Cool Valley (UCV). (Rizwan et., al 2008)

2.4.2 The albedo's function

Surfaces and pavements make up roughly 60% of city coverings Such dark surfaces generally collect and transfer more than 80% of daylight, resulting in many more urbanized areas, greater energy prices, and worldwide implications. Pavement repair with more reflecting materials might change this heating impact, increase walker comfort, and reduce the consequences of urban heat islands. Paving material can withstand temperatures ranging from 50 to 65 degrees Fahrenheit. in the summer, contributing to the heating of the air above them. More reflective surfaces may result from lighter paving materials.

Li H., (2012), find that increasing evaporation from pavement lowers the temperature, mean radiant temperature, and PET. As a result, thermal comfort in hot climates improved During summer, Pavement materials can reach peak temperatures of 50 to 65 °C, helping to heat the air above them. More reflective surfaces may result from lighter paving materials. According to Li, increasing evaporation from pavement lowers the temperature, mean radiant temperature, and PET. As a result, hot weather improves thermal comfort**.**

2.5 The Importance of Shading in Reducing Air Temperature

The objective is to increase the usage of constructed cover in personal and commercial locations that are more exposed to sunshine. Manufactured shading must be utilized as a temporary solution alongside shade forestation; built shading can be utilized as the main basis when nature is not a feasible shade alternative.

Cover constructions are beneficial for a number of purposes. It lowers the quantity of solar radiation absorbed by surfaces like pavements. A benefit is that built-in shade decreases UHI right once, while plants might take two to three years to develop sufficiently to offer appropriate shade. Lastly, the built-in shade is adaptable, easy to install, and may be commonly utilized as a public area. art. (EC2 2002).

According to Norton et al. (2015), the absence of greenery in urban areas causes the development of an urban heat island, which considerably raises heat damage for people and adds to illness and death. Methods are consequently necessary to minimize urban heat, especially given increasing urbanization climate change, and the incidence and strength of heat waves. In this study, we analyze the possibility of using sustainable architecture as a mitigation technique, concentrating on vegetation on the soil (parks) and foliage on structures (green roofs and green walls).

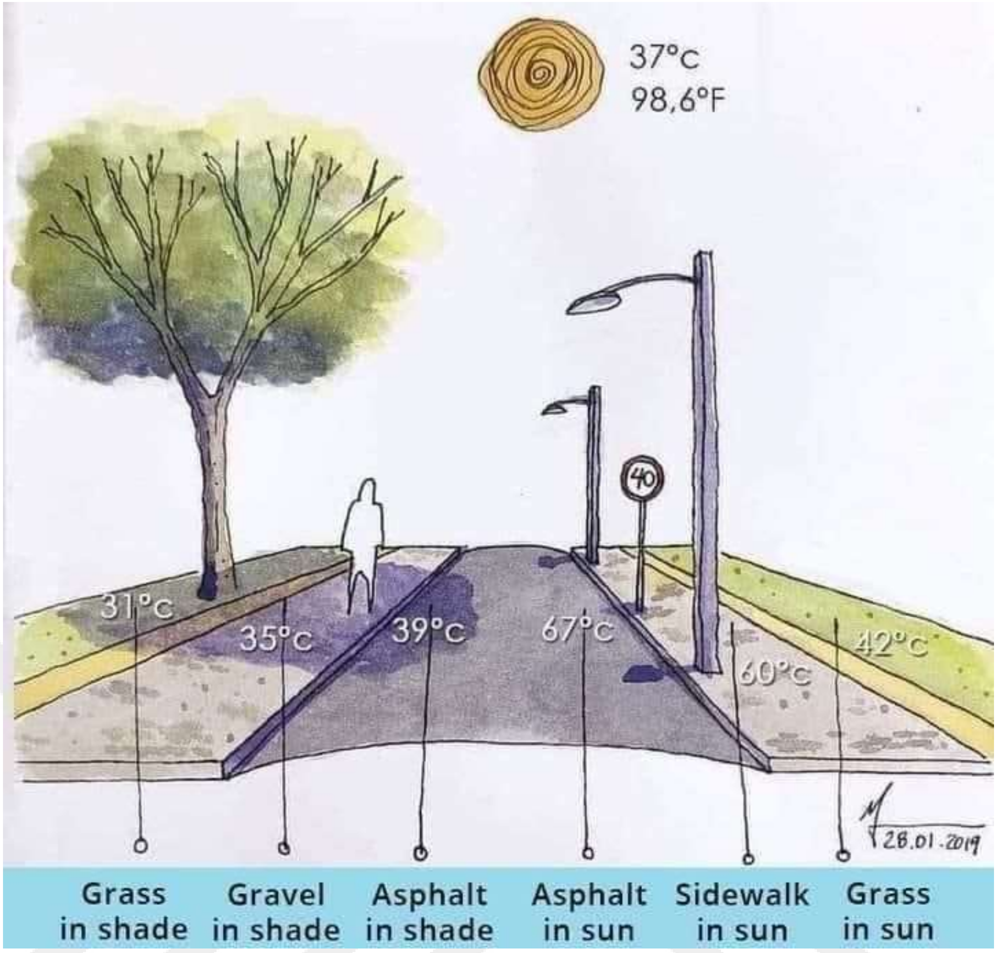

Figure 2.2: The Effect of Tree Shades

Source: Nacion Rotonda (2021)

Green building contributes to urban cooling by blocking sunlight and permitting drainage. Green space on the land often decreases peak air temperature by 2-9 degrees Celsius, while rooftops and walls minimize heat by 17 degrees Celsius while simultaneously contributing shielding to the exterior walls. Nevertheless, the chilling capacity varies greatly based on the As a result, urban planners should optimize the design to improve abatement benefits, such as peppering parks across cities, allocating more forest area than garden area, and employing diverse approaches in locations wherever chilling is much required. A better translation of science into practical design guidelines is required to accomplish this. (Wang and Akbari, 2016)

Figure 2.3: The Effect of Solar Reflection

Source: (image:heatisland.lbl.gov)

According to A Clear Guideline to Cooler Rooftop and Cooler Sidewalks, (2012), awesome coverings are evaluated by both reflectivity (SR) and heat emissivity (TE). Sunlight reflectivity is the most essential component in determining whether a surface is cold. It is critical to have cool roofing covering that is easily visible and extremely incandescent in order to lessen light conversion to heat and increase heat reflected off. Much all transparent objects refract some of the sun's rays while absorbing the remainder and turning it to warmth. Sun reflection, also known as albedo, is the quantity of light scattered by a surface. White rooftops reflect less of the sun's energy, converting less of it into warmth.

White rooftops reflected around 70 to 80 percent of the sun's rays, whereas black rooftops reflected no and over % (i.e., these surfaces have a reflectance of 0.2 or less).

In noon sunshine, white rooftops have a thermal resistance of 28 to 36 C. (50 to 65 Centigrade) from dark roofs; elderly white roofs have a thermal gradient of 20 to 28 C. (35 to 50 degrees Fahrenheit).

In addition to cooling, light-colored pavements offer a number of other advantages:

- Increased durability: Cool pavement materials are being tested in a variety of conditions to assess durability and longevity. Lower temperatures may reduce the risk of rutting on asphaltic pavements.
- Illumination at night: Light-colored pavements in parking lots and streets will improve visibility and safety at night, and may also reduce the need for street lighting.
- Improved water excellence: High asphalt temps can heat rainwater runoff, affecting the metabolic and breeding of plankton. The Environment Agency (EPA) has identified increased water temps as a major issue.

Plants transform liquid to liquid water using evaporation, which reduces the temperature of the leaf and ambient air and boosting heat transfer (Fahmy et al., 2010, Oke, 1988).

Old trees with a big LAI and top width can greatly increase outdoor weather enjoyment, per a simulated study of wind turbines setting in Wuhan. (Zhang et al., 2018).

2.6 The Characteristics of Urban Materials

Since they control how electricity is utilutilizede radiative and thermodynamic qualities of materials have had an influence on the formation of urban heat islands (reflected, emitted, and absorbed). Moreover, the large bulk of wood products, roadways, and pathways are impervious to wet. As a response, there is more accessible power for lengthy emissions, perceptive heat transfer, and contact conductance. The infrared absorption coefficient is a measurement of a surface's capacity to shed heat or emit lengthy (infrared) energy, as per Hove (2011). It is a totally subjective metric. It refers to the ratio of light radiated by a certain material to that radiated by an object at the same temperature. Any real item would have =1, whereas a true black body would have =1

Some substances have a reflectivity of 0.85 or greater. Masonry, steel, and some cement mixtures have lowish values. The widespread usage of these substances can reduce total urban transmittance, raising net radiation doses in cities. Several research investigated the possibility to improve albedo in order to minimize urban heat islands and conditioning power use. Albedo is defined as the ratio of solar energy absorbed. A city's albedo is determined by its surfaces, roof materials, and solar location (site latitude, date, and hour). (Bouyer and colleagues, 2009)

In Los Angeles, an increase in albedo lowered peak July temperatures by up to 1.5 K, according to Sailor (1995).

Taha (1999) found major progress in pervious surfaces for ten US cities lowered near-surface midday summertime air by 0.5 to 1.5K and peak power use by up to 10%.

Some qualities, like the thermal characteristics of urban surfaces, can be deemed more effective on urban materials. This is influenced by the volume, temperature-specific heating capacity, specific heat, and heat admission factors of the utilized.

Metal and granite, for example, have larger heat capacity than rural materials like dry dirt and sand. As a consequence, towns are often better than rural areas in storing sun energy into heat in their equipment. Of day, urban areas may collect and retain double even much warmth as their rural counterparts. (Hove, 2011)

Montavez et al. (2007) show that the best mix of shape and Excellent properties may provide a UHI level of 10 K, which is comparable to what is seen in actuality.

Oke et al. (1991) numerical experiments demonstrated that the properties of solids had a major impact. Thermal permeability discrepancies between rural and urban locations can cause heat (or cold) islands. Thermal permeability discrepancies are less evident and noticeable than geometrical variances. Thermal permeability is the amount of thermal movement between the interior surfaces of the building and the ambient temperature in the space.

Elsayed (2012) identified thermal admittance on the material's surface as one of the most important thermal properties in causing the Urban Heat Island. This property influences the amount of thermal flux through a substance at a given temperature profile. In general, temperature variation is inversely proportional to thermal admittance.

Oke et al., (1991) stated that cities with high admittances (wetlands, irrigated soils, paddy fields, or rock) could only support a small Heat Island.

2.7 Urban Heat Island Phenomenon

With recent technological advancements, many Remotely sensed and molecular dynamics methodologies were used in the investigation. Science has always provided a broad area's heat flux, which is generally then used to examine the in-betweening global temperatures and plant covering, as well as the variability of UHI impacts in large-scale cities or towns (Oke 2003).

Global warming is anticipated to exacerbate the global urban heat island (UHI) effect, raising the likelihood of heat-related illness and fatalities. Solar reflective 'cool concrete is one of the numerous mitigating measures that may mitigate the harmful impacts of the UHI effect. Heat-absorbing reduces as pavement albedo improves, leading to lower heat flow (Tsurface). Cool sidewalks placed at suitably large geographical scales might also lower near-surface heat gain (Tair), however, field tests have never proved this.

The Urban Heat Island (UHI) is a well-studied phenomenon in urban climatology that describes city heating in relation to neighboring communities. Reduced Urban Heat Island methods are an essential aim in architecture and urban planning, mainly in hot-weather cities.

2.8 UHI Mitigation Strategies

Remediation approaches try to balance the radiative networks of cities by boosting heat transfer and minimizing equivalent benefits. Among the effective steps recommended are those targeted at enhancing the albedo of the urban environment, expanding green areas in cities, and dissipating surplus heat through heat source sinks (Akbari et al., 2005).

Both properties minimize the quantity of heat storage in the fabric, which has an effect on the heat zone the next day.

Oke et al. (1991) The elements that may be implicated in tiny Urban Hat Island, such as the pale hue of many tropical building exteriors, which may lower absorbance owing to a greater albedo, were explored. As per Akbari et al. (2012), using nice ceilings and cool roads in urban areas can boost the average albedo of urban areas by around 0.1, and upping the albedo of urban roofs and roads globally will stimulate a bad solar activity by approximately to offset at least 40-160 Gt of CO2 emissions.

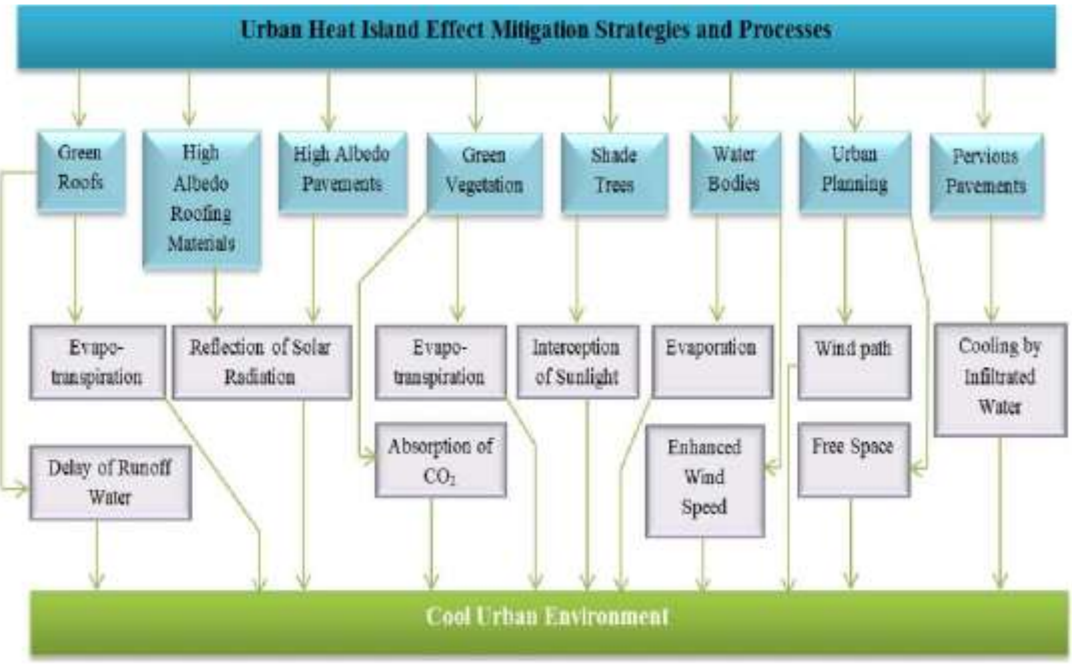

Figure 2.4: Urban Heat Island Effect Mitigation Strategies

Source: (Nuruzzaman, M. 2016)

According to Hadad et al ., (2021) The UHI effects of urban planning can be reduced with proper landscape design. Any potential strategy for mitigating UHI should, rather than be an exception, include a nighttime cooling effect because UHI is more noticeable at night. As stated by Nazarian et al., 2020, urban heat mitigation requires only the thermal characteristics of the urban area and not their differences from those of the surrounding rural areas. “The need for mitigation, the degree of mitigation required, and the efficacy of mitigation strategies must be determined only by the thermal properties of the urban environment To reduce UHI, different solutions like as constructing cool or vegetative rooftops, greening, and substituting paved areas with cool walkways can be employed. They discovered that green roofs covering 30% of the total roof area might lower heat flux by 0.06 ℃ in their investigation. According to a study, greenery in metropolitan areas may dramatically lower airflow on warm days.

2.9 The Effect of Streets Design on Urban Canyons

2.9.1 Urban microclimates and street canyon designs

A roadside gorge is an essential unit of cities, consisting of two normal series or parallel houses divided by a road. A roadway canyon's architecture is defined by its "ratio," which incorporates the ceiling height (H) towards the roadway width ratio (W). A homogeneous street canyon has an angle close to one and no significant cracks in the walls. A canyon with an aspect ratio less than 0.5 is classified as shallow, whereas a basin with a display size larger than 2 is classified as deep. The canyon height (L) is the distance between two major junctions that split the street canyons into short and long segments.

The shape and direction of the street canyon have been shown to influence outdoor and interior conditions, sun access both within and beyond dwellings, circulation fluidity for urban aeration, and the possibility of trying to cool the total urban system. As a result, built form affects both pedestrian thermal comfort and urban structure energy usage. The biggest challenge for the artist when planning a street from a climatic aspect is the seasonal shift in internal and exterior demands. In the heat, for the occasion, sun security can be achieved, whereas sunlight is required in the year. This suggests brevity and access to the sky in the idea.

Per the current research, the most significant urban characteristics relevant for climatological variations in a given area are the parameters of street ravine form (height-to-width ratio (H/W) and street direction. These variables do have a direct influence on the possibility for roadside airflow, sun exposure, and hence urban ecology. Despite substantial attempts by new and old architects to build urban streets in line with ambient, statistical knowledge well about best feasible streetscape scientific methodologies is still necessary in order to govern climatic comfortable.

2.9.2 The effects of street design on airflow

Urban airflow trends are determined by the interplay of an incoming wind with the building. The production of airflow inside a given area is vital to good wellness, outside and interior thermal comfort, pollution levels, construction power consumption, and the creation of a pleasant urban microclimate. The cooling impact of airflow, for one, might serve to alleviate the consequences of the urban heat island syndrome, difficulty sleeping.

Many studies indicate that the pattern of a regional wind alters when it travels among a constructed area.

As a result, designing the built environment, particularly street canyons, is an important factor in the formation of urban airflow patterns.

There are two sets of air surrounding cities: the urban canopy layer and the urban boundary layer. The urban canopy material is formed by the surface of roofs in the gaps among structures and is impacted by solar radiation falling on building facades and the ground. The average building height is greater than the urban border layer. Thermal transmission, pollution, increased runoff, and futuristic urban growth in fact are the key variables influencing air temperature in the urban flow region.

There are two sets of air surrounding cities: the urban canopy layer and the urban film thickness. The urban canopy vector is deposited by the surface of roofs in the gaps among structures and is impacted by ultraviolet irradiance falling on exteriors and the earth. The average building height is greater than the urban border layer. Thermal transmission, pollution, increased runoff, and futuristic urban growth in fact are the key variables influencing air temperature in the urban flow region.

Similarly to air motion over an empty obstacle, the solitary ruggedness phase happens if there's no contact among lee and downwind streams. By raising the H/W ratio, the sounds are affected, culminating in an actually woke disturbance regime. The road canyon gets separated from of the circulating air in the urban border zone as the H/W ratio grows, leading in the establishment of a continuous cardiac maelstrom in the canyon. The far more typical skimmer regime in metropolitan environments is caused by this steady circulation vortex. As a result, it is feasible to deduce that airflow in deep open areas is quicker than in uniform or shallow ones. (Shishegar 2013)

In addition, other research investigated the impact of storeys on airflow within a roadway canyon. When the airflow is parallel or perpendicular to the canyon, Wong et al., (2005) observed that carefully adding a few squares of mountaintops will increase velocity within the street canyon. Similarly, the mercury reduced when high-rise skyscrapers were built in a closed space. The velocity for parallel flow may be enhanced by up to 90% by creating certain high-rise buildings, while the warmth can be decreased by up to 1°C. Parallel flow boosts velocity up to tenfold while lowering heat by 1.1°C.

Moreover, Macdonald et al., (1999) It was revealed that by creating a few tall structures amid outer walls constrained in the urban canopy level, more disturbances cause more speack and Inverted tornadoes can form. Increased upflow north from the street canyon to the urban boundary layer would be caused by tall structures above. Imaginary vertical circulation from the urban border layer into the urban canopy layer would be caused by structures upstream. Moreover, appropriate air circulation inside the urban canopy layer is improved by suitable apertures between roads and squares.

Moreover, it was established by Samad et al.,(2001) that varied heights might give greater ventilation. As a consequence, tall structures do not encourage blockage in the first place. Moreover, they determined that a broader urban canyon supports greater air mixing and that roadway layout should be confined to a sweeping flow boundary, with a highest mean canyon length ratio L/H of no over than five.

2.9.3 Steet design's impact on solar access

The sunlight has a large influence on the weather. Solar radiation arriving in an urban area is absorbed either as building surfaces and rooftops or the ground among structures. The magnitude of sun radiation might negatively affect sunlight and hence thermal comfort at the different floor levels from the standpoint of the urban street canyon. As a consequence, constructing urban roadways to maximize sun availability in urban canyons is crucial for enhancing urban microclimates.

The direction of the roadway, according Arnfield (1991), has a bigger effect on the yield of solar collected by walls, and the H/W ratio impacts the availability of solar energy on the ground. Moreover, the orienting impact is larger in the summertime than in the cold. So they are covered in the summertime and visible in the winter, closing the borders oriented N-S (i.e. E-W streets) offer better annual solar management. The direction has minimal influence on the motorist's exposure. The sun's angle lowers in the winters in midlatitudes, posing substantial challenges. As a result, cable to connect falls at equatorial regions, notably in the E-W direction. The impacts of the H/W ratio and road direction on acquiring renewable electricity by pavement and many other street materials are more important at altitudes 20°- 40° in different seasons. This illustrates that in warmer areas, roadway shape is more significant for sun management.

R. Macdonald et al., (1999) The prior study was proved by examining the impact of roadway design characteristics (width and direction) on sunlight exposure to the urban canopy. They investigated four potential roadway widths: 10, 15, 20, and 25 m, as well as two distinct orientations: E-W and N-S. All calculations and simulations are based on actual meteorological data from De Bilt, The Holland, from 1995. (5206 N and 511 E).

Mayer et al., (2006) it was emphasized In addition to how streetscape impacts the outside weather; in the cold, sun access needs in inside areas usually travel urban geometry selections. Although raising the aspect ratio minimizes the possibility of cosmic rays on facades, wall position in regard to exposure is equally essential. For optimum solar acquisition, walls looking south are ideal; both east and west are options but have various drawbacks as compared to the south, while the northeast receives practically no sun rays. When both are taken into account, a ratio of thermal comfort outside and sunlight access indoors is required to assess the climatic effectiveness of road alternative solutions.

2.9.4 The ideal street orientation

The local weather must be considered while designing urban space. Geography, roadway structure, environment, a tower built form, and choice of materials may all help to minimize heat islands, modify Indian monsoon heat, and cut fuel burdens on structures. The urban design may greatly cut residential energy usage while also contributing to the establishment of a suitable public realm by providing shelter and chances for daylighting design. Solar radiation's effect, Atmospheres in various regions of a city can change by up to 15°C from convection, latent heat, albedo (the amount to which an item glows), and wind. Roads are significant in human perspectives of an area due to the principal thing where people engage because of they mix their purpose as a place and their position as a component of a vehicle transportation network. According to SAAD (2014), the streets will be directed as such.

2.9.4.1 Ideal street orientation in hot-area

To receive better sunshine in the cold and so less heat plus better shade in the summers, the best guidance to the sidewalks in the climates must be more on the axis (Northwestern) and the shaft (Northeastrn-Southeast) (Northwestern- Southeast).

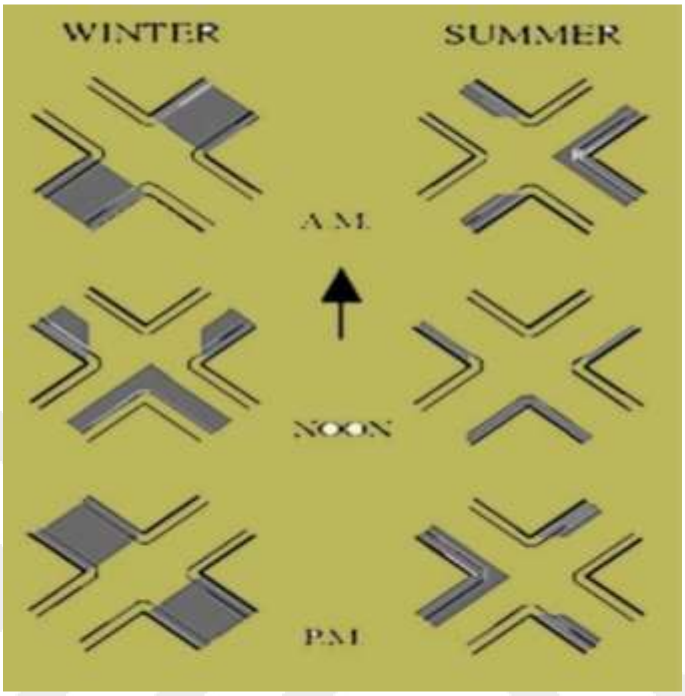

Figure 2.5: The Street Orientation in Hot Area

Source: McGraw-Hill (2003)

2.9.4.2 Ideal street orientation in cold-zone

The best guide to the streets in cold regions must be in the axis direction (North-south) and the axis direction (East-west) that it is investigating the best insolation in the winter and more heat and less shade in the summer.

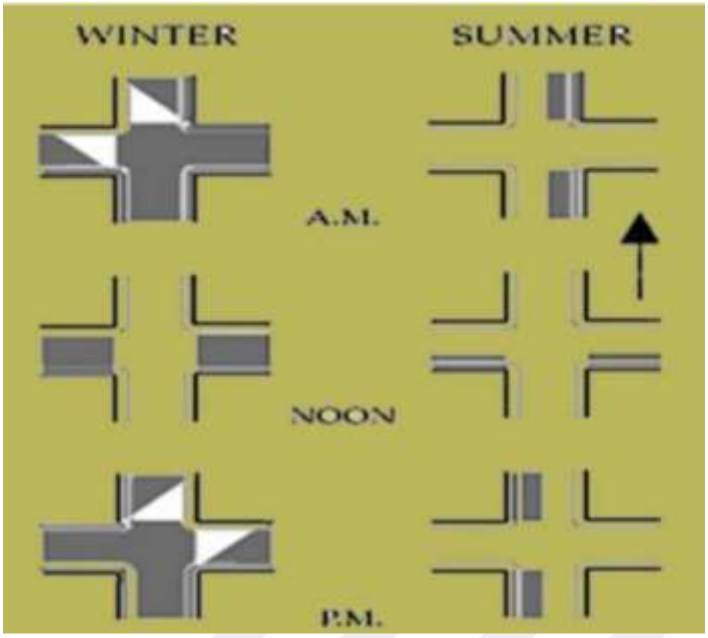

Figure 2.6: The Street Orientation in Cold Area

Source: McGraw-Hill(2003)

2.10 Effect of the Type of Material Types in Heat Cladding on the Ambient Temperature of Pedestrians

A study conducted by Al-Hamdi et al.,(2006) revealed the importance of natural finishing materials, It has been found by experience that natural stone coatings reduce the temperature of internal and external spaces in hot, dry areas by reducing the temperature of both. When the temperature of the outside air is between 49°C and 25°C with a daily temperature range of 24°C results in a natural stone cladding air temperature range of 40 m to 38.5° on the pedestrian paths.

Waleed (2010) approved that

- Compared with other materials, asphalt has the worst thermal performance because it negatively affects the surrounding air temperature.
- The use natural stone is best used in floor coverings, as it reduces the temperature of the surrounding air.
- The air temperature over the concrete material is approximately 1.2˚C higher than that of natural stone.

Grados et al., (2018)investigated the thermal response of five French asphalt constructions during a warm in a lab. The influence on air temperatures was investigated in a study of the thermal characteristics of the asphalt mixture and the surrounding layers. At various depths, both heat flow were monitored. Figure 7 depicts the samples utilized in this investigation, which included asphalt road, bitumen pavement, stabilizing sand, granite walkway, and grass. The specimens are split into multiple organizations based on the heat transfer at the finish-the-day phase: "hot" resources such as asphalt side walk that attained 60 ° C., "cool" resources such as stable dust and natural stone pavements that reached 55 ° C., and "quite cool" equipment such as lawn that reached 40 ° C.. At nighttime, data are sorted into two classes: "cold materials," such as stable sand and vegetation, and "hotter equipment," which include all other data.

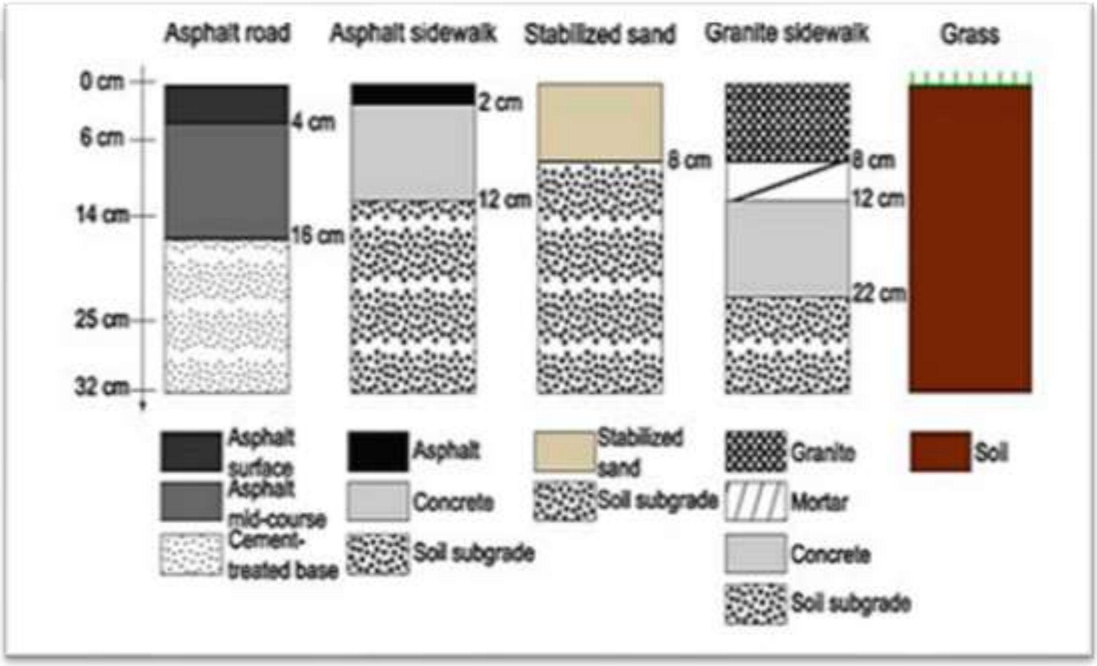

Figure 2.7: The structure of the studied pavement sample

Source: Grados et al.,(2018)

Low-albedo materials had the largest influence on air warming, based on the findings. So when the ambient temperature is 35°C and the spectrum irradiation is 320 W/m2, the daily limit heat flux declines by about 3.4°C for every 0.1 rise in albedo. Excluding the stone curb construction, every test behaved similarly to dark buildings during the night period. Stone is a very exuberant and fluid substance, and this explains this is the case. Granite constructions can store a tremendous amount of heat during the day and swiftly dissipate the warmth they have stored at night. The paper develops a solar transfer index to illustrate the capacity of materials to transfer energy absorbed in depth. This index is dependent on the depth, reflectance, albedo, width, and permeability of the overlaying material layers. Under the same incoming radiation, the surface layers with more conducive and washable surfaces convey the most heat inside the building.

2.11 Urban Heat Island Flow Chart

75 researches were evaluated, and it was discovered that vegetation cover effect on UHI with percentage (44%) , a yearly cycle (33%), street orintation (28%), day-night (25%), and population density (14%). Such elements may be split into two categories: non - controllable situations (Figure 2.9), which are further subdivided into momentary (the influence of wind, cloud cover, for example), continuous (green spaces, shade, empty sky view), and cycle (solar radiation, evapotranspiration, e.g.). (Deliami et al., 2018)

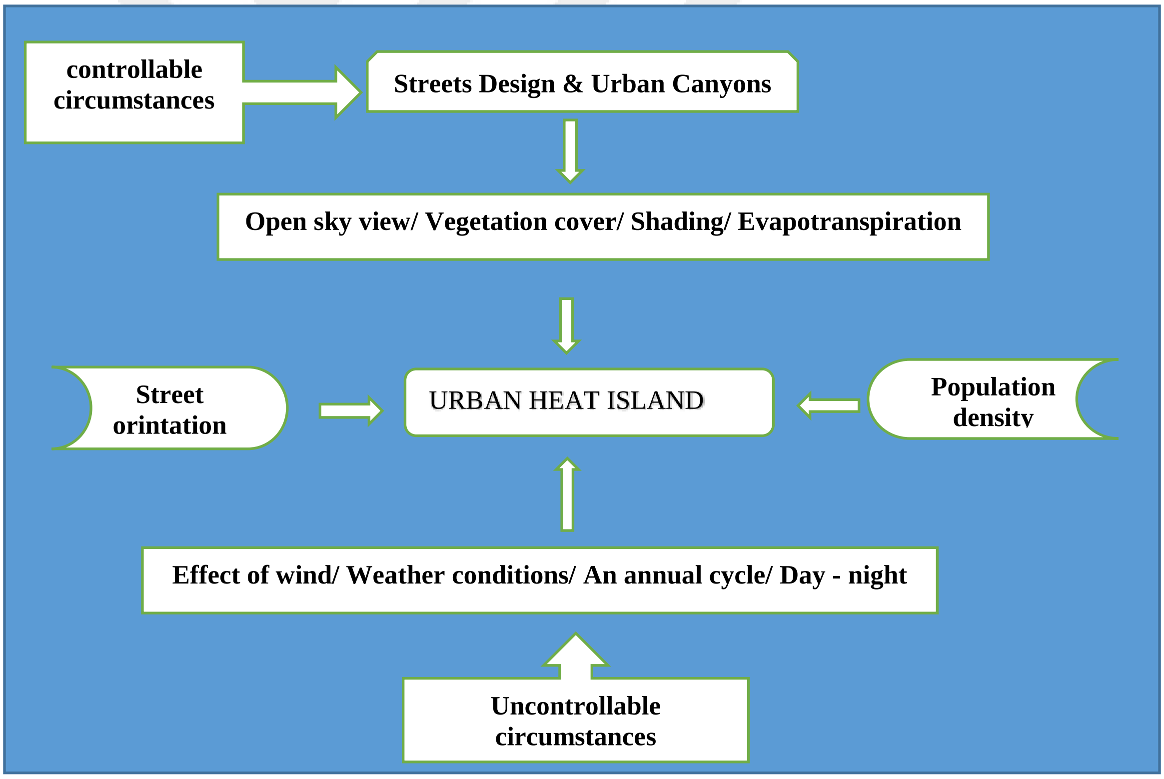

Figure 2.8: Urban Heat Island Flow Chart

3. THE CHARACTERISTICS AND FEATURES OF THE COMPUTER PROGRAM ENVI-MET

3.1 Abstract

The ENVI-met program simulates microclimates in urban environments. This program simulates the urban climate in cities and can assist new towns in planning their environment.

3.2 Modeling of Urban Microclimates Using Numerical Methods

Two levels of activities influence the sensory consciousness of atmospheres. Big mechanisms influence the passage of air currents in the higher levels of the tropics. These huge dynamics generate what we term "climate" by determining the movement and interchange of air currents with diverse attributes throughout the world. Furthermore, fewer events exist in the troposphere's bottom layer. The precipitation is also impacted by operating inside this layer, but the communication activities among the earth, moisture, structures, vegetation, and the sky generate a unique ambiance that may either increase or counteract sizable climate events patterns.

One of the advantages of the microenvironment is that people may change it immediately and practically instantly. The finest illustration of humans' effect on the environment is urban heat islands (UHI). The term urban heat island refers to the finding that warming in towns can be much greater than in adjacent rural regions. Because of the intricate connections and quasi-relationships between the various characteristics of the microenvironment, it is rarely viable to formulate broad rules for climatological favorable urban planning and architecture.

A technique that may be advantageous in one city, such as improving wind flow, may have unintended consequences in another town with such a different climate (mesoscale). The bioclimatic simulation tool is thus the most effective instrument available to urban planners and architects for assessing the influence of their individual initiatives on urban microenvironment.

Nanoscopic simulations used in study and urban planning are limited to a specific component of microenvironment and so do not suit all criteria. In other models, such as MISKAM (J. Eichhorn, 1989) or MUKLIMO 31 (U. Sievers, 1995), the emphasis is primarily on wind directions and chemical and particle patterns within the environment, whereas thermodynamics effects and building heat flow are ignored. Achieve desired (Lindberg et al., 2008) and Rayman (Matzarakis et al., 2007) models mimic light distributions inside cities. (Mahrer et al.,1984), on the other hand, focuses solely on symbioses.

3.3 ENVI-met: The Environmental Monitoring Program

ENVI-met is a three-dimensional environmental modelling approach. The model's time and geographical precision distinguishes it from large-scale simulations used to anticipate daily precipitation or future climatic. ENVI-met is a microscopic level modeling of the interplay among the environment, soil, plants, highways, and structures with average different magnification varying from 0.5m to 10m and temporal increments of 10s. As any vegetation as each urban structure may be precisely reproduced, ENVI-met is the ideal tool for urban planners, builders, and urban meteorologists who aim to mimic the climatic elements of the urban setting.

Previously, such complex assessment methods were not required in urban planning. The patterns of urban design became more complex beginning in the mid-twentieth century, Especially during the 1990s, when ecology become the continuous challenge.As a result, in the last decade, there has been a significant increase in the use of simulators to gain a better knowledge of urban microenvironment and electricity costs, as well as how it may effect construction Between all various models of urban meteorology that allow for urban reactions, ENVI-met is nearly the only program competent of accurately measuring walker thermal comfort, all climatic factors, and all urban ground and plant thermally interplay. It can quantitatively integrate diverse ground and vegetation kinds and compensate for solar motion at every place with a small amount of inputs.

the use of simulators to better knowledge of urban microenvironment and power use and when it can effect architecture As among various programs in the field of urban climatology that account for urban ecological events, ENVI-met is practically the only program able of accurately measuring walker thermal comfort, all climatic variables, and all urban ground and plant thermal interrelations. It can quantitatively integrate diverse topsoil and plant kinds with a small number of inputs and account for sun motion at every place (Damour et al., 2013).

The computer may deduce the plant's mesophyll activity by calculating net plants growth use the connection. The ENVI-stomatal met's theory, between others variables, takes into account the essential parameters that restrict net sunlight and consequently nodulation:

- Insufficient solar irradiance light
- insufficient CO_2
- insufficient water availability

Transpiration speed, leaf heat flux, roots water availability, photovoltaic active energy absorbed, and beginning of this story impedance are some of model's predictive output factors. The factory model combines the approach findings of individual plant grid cells of leaf area density to create an incorporated life form - a tree - from which inferences regarding biological and weather patterns characteristics may be drawn at the seedling stage instead of at the grid cell level.

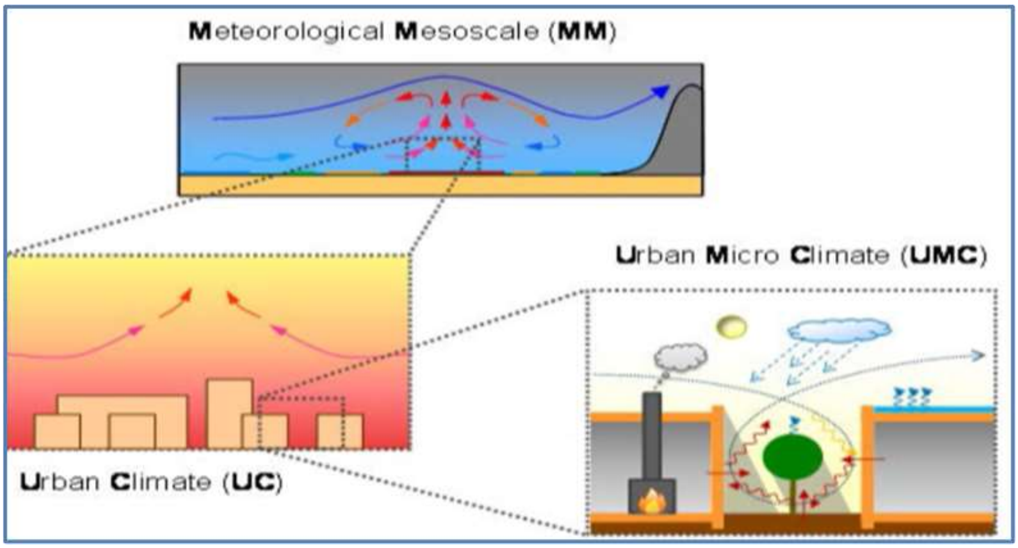

Figure 3.1: A Multi-Scale Approach to Modeling Urban Microclimates

Source: Dorer et al., (2013)

Idczak et., al(2010) performed a research to validate the heat transfer concept (SOLENE) and its use for assessing the road canyons energy In the afternoon, heat produced was transported predominantly from ravine walls to surrounding atmosphere, as well as from air to land. Throughout the day, the canyon's total albedo ranged between 0.20 and 0.25, but plummeted to 0.10 in the evening when the earth substantially turned indirect and reflecting solar energy into heating. The statistics was selected to validate the capacity of the thermal properties model (SOLENE) to replicate the thermal properties activity of a roadway.

The influence of Urban Heat Island in France was explored using a computer modeling method TEB (Town Energy Balance) urban system and the computational weather system Meso-NH (Lemonsu et al., 2002). To assess the meteorological impacts of Parisian on the stretching sheet, Meso-NH is utilized in combination with a basic model. According to the findings, the UHI over France can reach 8 degrees Centigrade at nighttime, while the UBL has severe volatility and volatility in the daytime. In 1991, Johnson created a computer model to study the heating of rural and urban valley slopes during calm, clear nights. Again for system to operate, a systems of nonlinear nonlinear problems should be resolved.

The simpler method to this concept is called as (SHIM), which refers for Thermal Radiation Island Mechanism. Heat flow across the vertically and horizontally levels, in addition to radiation exchanges in both the skies and the substrates, are all part of it. The study discovered but under (ideal) circumstances, the basic (SHIM) model may be utilized to identify Urban Heat Island cause. In choosing a strategy, the specifics of the outcomes are viewed as the most essential element. The CTTC mathematical model was created by (Swaid et al.,1993) for estimating air climate changes in the urban canopy layer UCL.

Again from standpoint of this investigation, this study implies that scenario emulator was well selected. The technology used in determining the relevance of the architecture on the various exposures and ambience, in this example, ambient temperature, is significant seeing as of its accessibility and reliability. (Chen and colleagues, 2012), (Yang et al., 2012).

Nevertheless, the inputs are considerable, and the majority of them are accessible; moreover, the simulation would not represent a major event (Salata et al., 2016). Envi-met application supports a prediction models using fluid mechanics and entropy. The model evaluates the interaction among external walls and vegetation by simulating surface-plant-air interaction in three components.

3.4 Characteristics of ENVI-met

By examining meteorological science and heat transport principles(Bruse and Fleer, 1998), the ENVI-met model replicates the characteristics of the urban microenvironment. To compute 3D wind flow in non-hydrostatic, non-incompressible situations, the Equations approach to the Advection - diffusion solutions is utilized. Katul et al., (2003) said that the minimal roughness closing approach is critical for effectively modeling flow data of the second element. Several prominent technical concepts are 1.5 closing types, often known as k- designs. Heat and water sources and drains are employed in the model to generate maximum temperatures and particular wetness patterns. Breuse and Fleer ,(1998) provide clear descriptions of the principles driving the system The modeling procedure in ENVI-met typically takes 24 to 48 hours. It is best to start a simulator at midnight or at dawn so that it can comply with atmospheric processes. ENVI-met must be given an input region that specifies the geometric shape of the target location, which been shown, plants, ground, and sensors. Weather data, urban geometry, material attributes, and plant features are all included in ENVI-met models. According to a research conducted by (Huttner et al. 2008), ENVI-met has a restricted maximal amount of grid cells, which makes it difficult to replicate the environment of an entire metropolis. It should be highlighted that ENVI-met lacks a human element that might assist.

Grid cells are used in ENVI-met whose maximum grid size is (250 x 250 x 50)m. A vertical grid can be specified in ENVI-met (http://www.envi-met.com/) in two different ways:

Based on the grid of equidistant points in Figure (3-2), the first cell closest to the surface is divided into five equal sections, each with a height equal to 0.2 Δz, where z is the grid cell height. All other model heights are constantly based on Δz

1- Vertical resolution is determined by a telescoping grid. With an extension (or telescoping) factor specified by the user, the grid size expands with height.

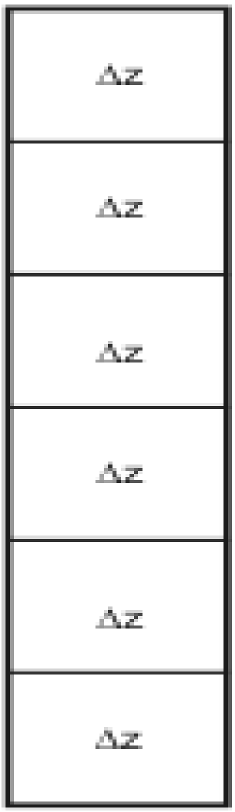

Figure 3.2: ENVI-Met Equidistant Vertical Grid Diagram

Source: (http://www.envi-met.com/).

Envi-met vegetation models are based on one-dimensional columns with height p z in which the leaf area density profile of trees represents the amount and distribution of leaves (Bruse et al., 2008). From the surface to the root depth, the root area density, (RAD), represents how roots are distributed within the soil system. This way, you can model all kinds of vegetation. Four sub-models make up the vegetation model; The turbulence flows of warmth and moisture semi, which addresses relationships among air with plant leaf, is the second one.. Furthermore, it addresses the linkages between liquid vaporization and transpiration from the soil via a plant with low eustachian tubes barrier. Evergreen foliage of plants contain cell walls per square kilometer, which indicates the barrier absorbed rainwater may experience when it dissipates from leaves, ranging from grassland to huge trees. Root system susceptibility is influenced by soil water and ultraviolet sunlight. Third, we consider the stable leaf energy cost, which is affected by foliar albedo as well as the transmittance ratio, FTr, which regulates net brief radiation absorbing. Water evaporation first from soil is computed in the fourth parameters defining using the hydraulic dispersibility of the ground via its strata. (Bruse, 2008).

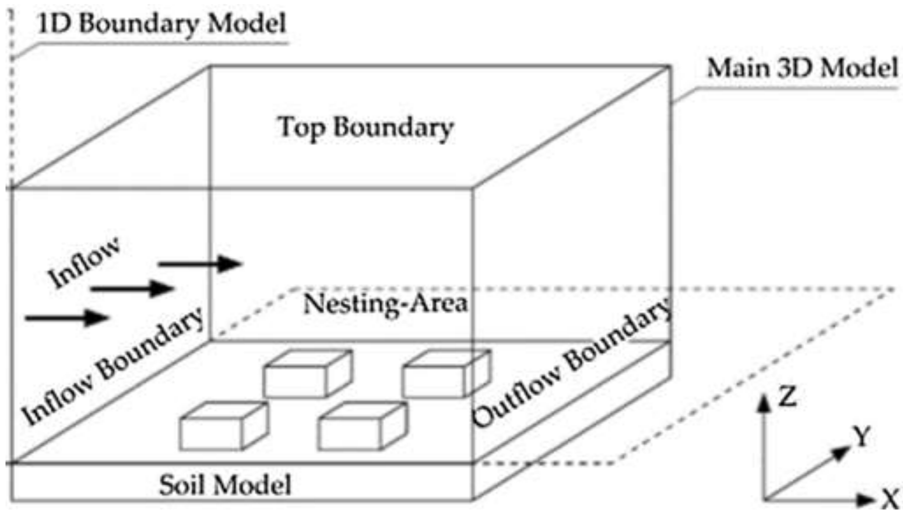

Figure 3.3: An Overview of ENVI-Met's Basic Software Model

Source: Jin et al.,(2017)

There are certain characteristics and purposes associated with each environmental modeling system. Beckman et al. (1993) present three main goals for designing and able to see past models that may be used to explain the segments and sub meteorological behaviour of design of components and landform in this research.

The three objectives are as follows:

1- Forecasting future behavior under various scenarios, i.e. to inform a decision-making process (for example, project development/evaluation, impact analysis, building design rules, and planning regulations).

2- Research into the mechanisms that generate behavior patterns but are not sufficiently supported by theory or empirical evidence as a basis for designing additional assumptions (principles that shape, advancement),

3- An clarification of how a specific input perturbation of the framework resulted in a specific output variable (the influence of distinct morphological changes in the surroundings), and reconciling of the findings with the concepts encapsulated in the prototype.

3.5 Factors Affecting The Human-Biometeorological System

The significance of Tart for comfort and the difficulties in determining it ENVI-met provides a decent estimate of Tmrt at the main street, which again is stated as follows for every grid cell (z):

Tmrt = (1 σ (Qlw,in + ak ε ∗ (Qsw−dif f,in + Qsw−dir,in))0.25   Eq   **(3.1)**

Surfaces of buildings, free atmospheres (sky), and ground surfaces make up the surrounding environment. A total of includes direct irradiation, all light fluxes It(z), diffuse and sparsely reflecting total solar Dt(z), and lengthy energy $E_t(z)$ are all kept in mind from the environment, earth, and barriers. The upper part of Et is thought to be (z) is generated by the sky and the lower half is generated by the earth. To calculate Tmrt at street level, we use the following approximation, because radiation from the ground will decrease with increasing height; $E_t(z)$ is calculated as follows:

$$E_t(z) = 0.5\left[\left(1 - \sigma_{svf}(z)\right) R_{lw}^{\leftrightarrow} + \sigma_{svf}(z) R_{lw}^{\downarrow,0}\right] +$$

$$0.5\ \varepsilon_s\ \sigma_B\ T_0^4 \quad \text{Eq (7)}$$

Heat flux can be computed for the real thermal resistance T_0^4 just at grid cell (z) considering sunlight into consideration 3. svf weights the upward ray flux 0 Rlw produced by the viewable sky. $R_{lw}^{\downarrow,0}$ denotes the lengthy radiated by the sidewalls. by considering the average building surface temperature Tw:

$$R_{lw}^{\leftrightarrow}(z) = \left(1 - \sigma_{svf}(z)\right) \varepsilon_w\ \sigma_B\ T_w^{-4} \quad \text{Eq} \quad \mathbf{(3.2)}$$

The total diffuse radiation $D_t(z)$, reflected partly by the wall and partly by the sky, can be expressed as follows:

$$D_t(z)\sigma_{svf}(z) R_{sw,dif}^{\downarrow,0} + \left(1 - \sigma_{svf}(z)\right) \bar{a}\ R_{sw,dir}^{\downarrow,0} \quad \text{Eq} \quad \mathbf{(3.3)}$$

where a represents the mean albedo of the model area. One part of direct solar irradiance is absorbed by the irradiated parts of the human body. An expression for this is the projection factor f_p determined by the height of the sun φ and given by:

$$I_t(z) = f_p\ R_{sw,dir}^{\downarrow}(z) \quad \text{Eq} \quad \mathbf{(3.4)}$$

$$f_p = 0.42\, cos\, \emptyset + \ 0.042\ \ sin\, \emptyset \qquad \text{Eq} \qquad \mathbf{(3.5)}$$

3.6 A Model of Physics

ENVI-met calculated the following significant prognostic variables:

The air temperature and the soil temperature

- Humidity of the air and soil
- The speed and direction of the wind
- Dispersion of gases and particles
- The fluxes of radiation

These variables must be computed using several sub-models that are combined. The ENVI-met sub-models are shown in figures (3.4) below:

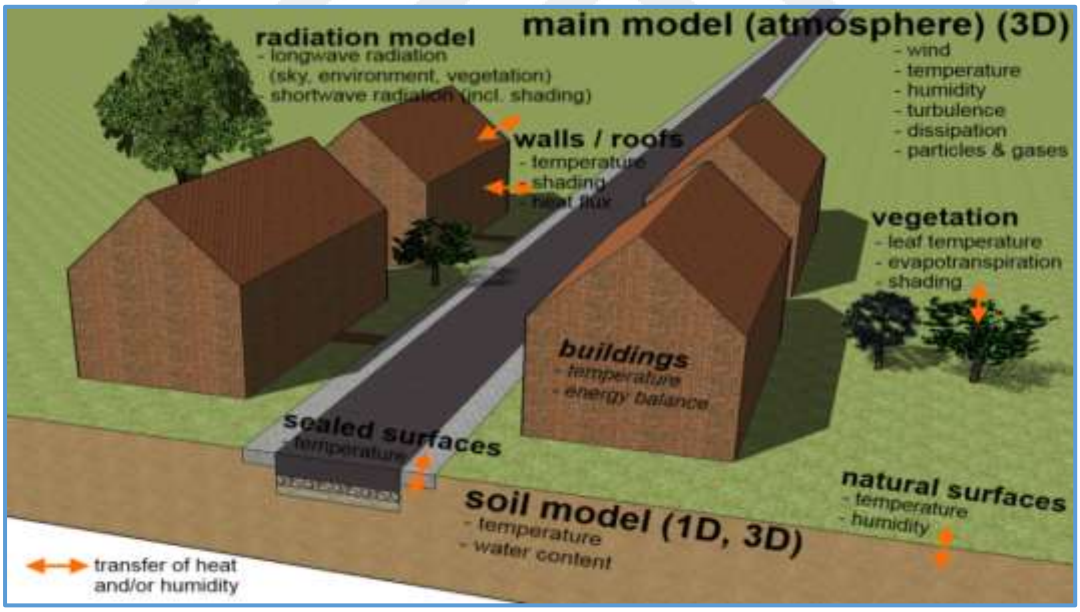

Figure 3.4: ENVI-Met Sub-Model Diagram

Source: Huttne r(2012)

3.7 Preliminary Conditions

Modeled in three dimensions, three horizontal (x, y) and one vertically (z), the main component consists of two vertical dimensions (x, y). This main model represents typical building and vegetation elements, The schematic of the ENVI-met model layout can be seen in figure 3-3 .

3.7.1 Weather report

Input parameters for the initial temperature at a height of 2500 m specify the temperature for the entire vertical profile under neutral conditions. Whenever the When the heat differs from that of the air, a horizontal gradients forms. The vapor pressure pattern is continuous utilizing inputs at 2500 m and moisture content at 2 m. Suppose that tearing force is altitude invariant and equal to the squared of average speed outdoors, and that turbulent values are equal at 2500 m. The 3D model offers the surface moisture content as overall mean of the housing provisions variables.

3.7.2 Preliminary soil conditions

To The 1 D model uses three inputs of soil moisture levels to determine the surface degree. The heat is kept steady while mimicking deep dirt (-2.00 m) ,(http://www.envi-met.com/).

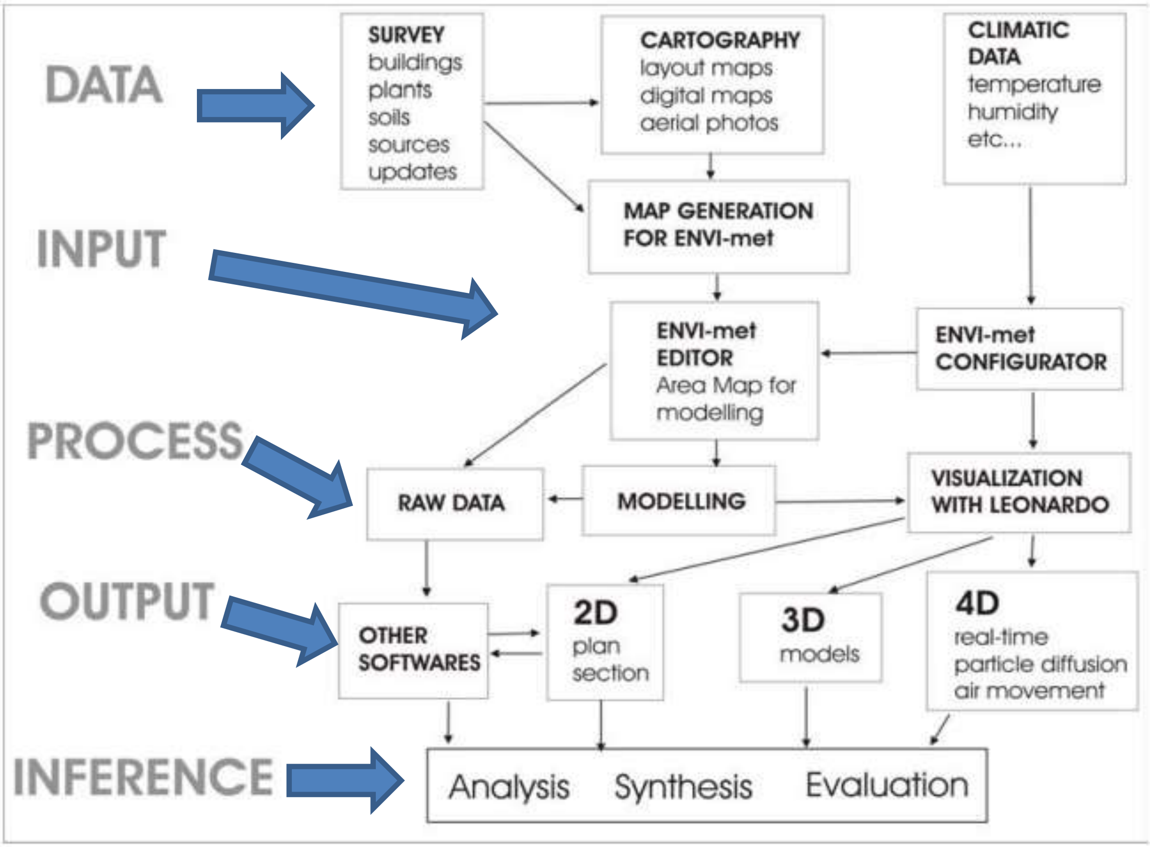

Figure 3.5: Modeling Process in Research

Source: Brazel et al.,(2003)

3.8 Physical Properties of the Atmospheric Model

An Winds movement, instability, warmth, moisture, plus short- and lengthy light fluxes are all predicted by an environmental computer, as follow;

3.8.1 Humidity and temperature

Possible temperature distributions θ (K) and relative moisture q ($KgKg^{-1}$)) inside the atmosphere can be calculated by combining advection-diffusion equations with internal sources/sinks (Bruse and Fleer, 1998):

$$\frac{\partial\theta}{\partial t} + u_i \frac{\partial\theta}{\partial x_i} = K_h \left(\frac{\partial^2\theta}{\partial x_i^2}\right) + Q_h \qquad \text{Eq} \qquad \mathbf{(3.6)}$$

$$\frac{\partial q}{\partial t} + u_i \frac{\partial q}{\partial x_i} = K_q \left(\frac{\partial^2 q}{\partial x_i^2}\right) + Q_q \qquad \text{Eq} \qquad \mathbf{(3.7)}$$

Q_h and Q_q are used to Combine temperature and moisture exchanges at the soil surfaces with an environmental simulation. Huttner (2012) demonstrated that is the turbulence transfer ratio for energy and specifies the heat transfer for both the wind and the plants. He further highlighted that is the turbulence transfer ratio for moisture and specifies moisture interaction among wind and plant. According to (Huttner 2012), ENVI-met doesn't really mimic the phase transition from two fluids.

3.8.2 Processes of turbulence and exchange

Local agitation generation consistently surpasses absorption in breezy situations, thus the average flow transfers the unstable ripples. Using the findings of Mellor et al. (1975), two new factors are introduced: turbulence energy of motion and its absorption. Bruse et almodel .'s now includes two extra formulas for local instability () and its rate of dissipation ()., (1998).

$$\frac{\partial k}{\partial t} + u_i \frac{\partial k}{\partial x_i} = K_k \left(\frac{\partial^2 k}{\partial x_i^2}\right) + P_r - T_h + Q_k - \varepsilon \qquad \text{Eq} \qquad \mathbf{(3.8)}$$

$$\frac{\partial\varepsilon}{\partial t} + u_i \frac{\partial\varepsilon}{\partial x_i} = K_\varepsilon \left(\frac{\partial^2\varepsilon}{\partial x_i^2}\right) + c_1 \frac{\varepsilon}{k} P_r - c_3 \frac{\varepsilon}{k} Th - c_2 \frac{\varepsilon^2}{k} + Q_\varepsilon \qquad \text{Eq} \qquad \mathbf{(3.9)}$$

The terms P_r and T_h explain both the generation and dispersion of chaotic energies and are the local source words for the creation of disturbance at plants.

3.8.3 A surface of the ground

Based on the energy balance, (Huttner 2012) calculated the ground surface temperature as follows:

$$Q_{sw,net} + R_{lw,net}(T_0) - G(T_0) - H(T_0) - LE(T_{0,}q_0) = 0 \qquad \text{Eq} \qquad \mathbf{(3.10)}$$

There are two types of net radiation at the surface: short-wave radiation $Q_{sw,net}$ and long-wave radiation $R_{lw,net}$.

G is the soil heat flux, H is the sensible, and LE is the latent turbulent heat flux.

With $R_{sw,dir}(z = 0)$ and $Q_{sw,dif}(z = 0)$, the direct and diffuse radiation of the shortwave can be summed as:

$$Q_{sw,net} = (cos\beta^*.Q_{sw,dir}(z = 0))(1 - a_s) \qquad \text{Eq} \qquad \mathbf{(3.11)}$$

- β^* is the Angle between incoming radiation and the surface normal. a_s is the property of the surface's albedo.

The turbulent flux H and LE are a function of turbulence coefficients K_h, K_q calculated on the ground surface and the lowest grid cell of the atmosphere (Huttner, 2012):

$$H(T_0) = \rho c_p K_h^0 \frac{T_0 - \theta_{k=1}}{0.5\Delta z_{k=1}} \qquad \text{Eq} \qquad \mathbf{(3.12)}$$

$$LE(T_{0,}q_0) = \rho L(T_0) K_q^0 \frac{q_0 - q_{k=1}}{0.5\Delta z_{k=1}} \qquad \text{Eq} \qquad \mathbf{(3.13)}$$

As a result, the soil heat flux G is calculated as follows:

$$G(T_0) = \lambda_s(k = 1)\frac{T_0 - T_{k=-1}}{0.5\Delta z_{k=-1}} \qquad \text{Eq} \qquad \mathbf{(3.14)}$$

Bruse et al.,(1998) finds the lengthy net irradiation was shown to take into consideration the influence of plants, long-wave fluxes from structures, and radiated reflections between structures. There are distinctions in the formulae for lengthy and leaf radiation b. According to (Huttner 2012), the earth phone's lengthy energy equation may be categorized into two components:

$$Q_{lw,net}(T_0) = \sigma_{svf} Q_{lw,net}^{sky}(T_0) + (1 - \sigma_{svf}) Q_{lw,net}^{screened}(T_0) \qquad \text{Eq} \qquad \textbf{(3.15)}$$

A sky view factor (σ_{svf}) determines the surface view $z = 0$ (Bruse et al., 1998). $Q_{lw,net}^{sky}$ This is long-wave radiation for the part of the sky with an unhindered view, $Q_{lw,net}^{screened}$ this is long-wave radiation for the screened part (vegetation, buildings block the view) (Huttner, 2012).

3.9 PMV and ENVI-met

Despite the advantage of the ENVI-met in calculating pedestrian comfort, the PMV scale in version 5.03 resolves the deficiency from the point of view of the adaptive model because it fixes human biometeorological input with regard to adaptation or psychological adaptation. PMV (Mean Expected Rating) is a measure of human thermal comfort based on the body's energy balance. Normal PMV values in ENVI-met range from -4 (extremely cold) to +4 (extremely hot), but can also vary widely based on the constructed surroundings, place, year, and time of day The ENVI-PMV met's models has been adjusted to account for short-wave irradiation and transitory weather situations rather than interior settings. (Jendritzky et al. 1979; Jendritzky and Nübler 1999).

ENVI-met has not yet published either BETA3.2 or version 4.0 (which employs actual metabolic temperature, PET, as a discomfort measure) as of the end of May 2010. Furthermore, while the program calculates Tmrt, it cannot be used as a comfort metric since it does not factor for RH or wind save for the irradiation of all wavelengths absorbed by walkers (Ali-Toudert and Mayer, 2006).

3.10 ENVI-met Research at UHI

Scientists are utilizing ENVI-met tool to make models to test the impacts of urban heat islands. Huttner et al.,(2008) studied how climate change impacts temperature sensitivity by employing ENVI-met in central European towns. It was suggested that green areas be considered an essential role in increasing indoor temperature.

Hedquist et al., (2009) finds that ENVI-met and CFD were used to simulate the daily changes in local airflow produced by the UHI. Using software resources and recognizing plants, plants, and construction materials in the specific location increased and enhanced the ENVI-met model inputs. The dynamics of UHI within the building design, based on this research, might potentially give methods to decrease warmth and boost thermal comfort outside in hot, dry cities. Are using ENVI-met meteorological model in conjunction with the Energy Plus power emulator, Yang et al. (2012) proposed a method for assessing building energy performance for an urban environment. The Energy Plus model and the ENVI-met model are illustrated in Figure (3.5). Various microclimatic factors can be quantified as influences on building energy performance under various urban contexts according to the results. In urban planning and building design, the method could be useful.

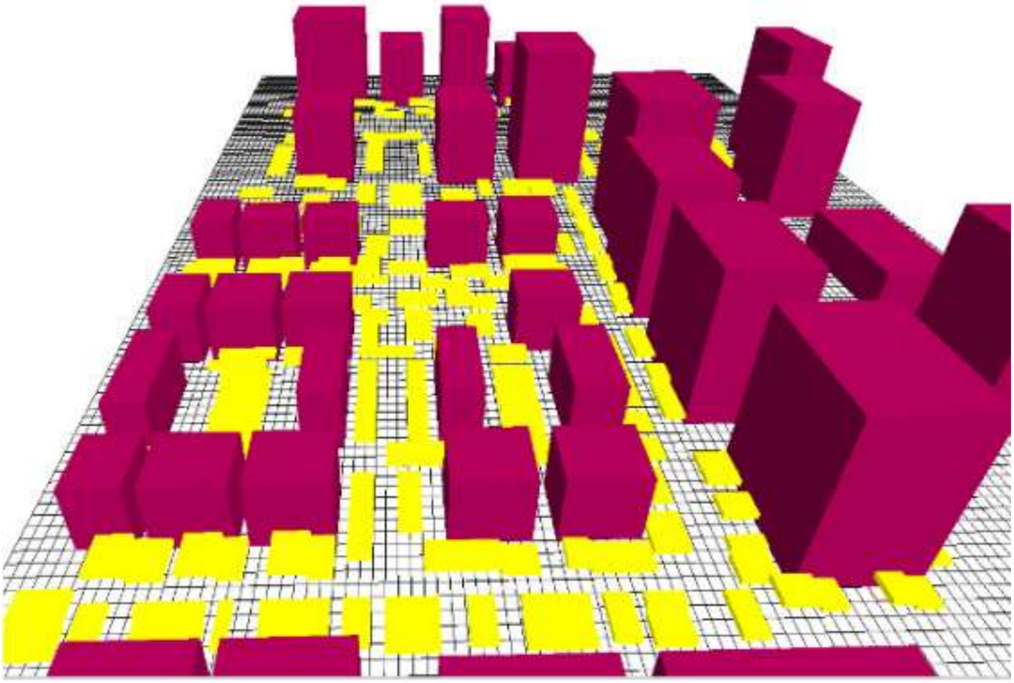

Figure 3.6: 3D Model of ENVI-met, With Urban Shading Devices in Yellow and Buildings in Red

Source: Norford et al.,(2019)

The area was or before in Cad prior work commences in ENVI-met. This application, edition 5.3, can reconstruct the entire town depending on a raster picture extracted from an AutoCAD file. The picture serves as a foundation. The size is adjusted depending on the pixels in the application. Every pixel equals 4 m in accomodate the entire town into the 180 × 180 model. First, a basic file was produced, then a second file containing shading. Models were built in the map area and then brought into the simulation settings where parameters were set. Streets, pavement, asphalt, and building typology and height are defined in the map area. A 2D plan is being complemented by a 3D model. To make the 3D model lighter, a scale factor is applied to the 3D model based on the varying heights of the buildings. 180 ×180 grid cells make up this model. Using the ENVI-met software, the second uses a more detailed scale (the lowest resolution is 100 × 100 and the highest is 250 ×250). There were some difficulties in defining height. A parallel 3D model and 2D plan are being built here. During dry conditions, the top layer of the soil performs poorly, according to a Singaporean study. According to a second study conducted in Melbourne, the soil layers account for an overestimate of sensible to latent heat flux due to a limitation in vertical moisture transfer. As a resul.

There are no window divisions in the walls of the buildings, but there is a new wall that is average in characteristics. The green shading is based on a tree with local characteristics, a height of 5 meters, and roots capable of taking water from the soil. Considering the planting of the specified types of plants, the tree's thickness may reach 0.5 m instead of 1 m. The shading devices (urban structures that shade parts of streets) are not linear, but interrupt to improve air circulation.

3.11 ENVI-met Features

As a simulation program, ENVI-met has some additional basic design features, such as:

1- Incorporate fluid mechanics, thermodynamics, and pollutant dispersion into the simulation of the complete coupled climate system.
2- Provided high-resolution models that resolve individual buildings.
3- Photosynthesis modeling of surface characterization.
4- Utilization of state-of-the-art computational techniques.
5- A user-friendly interface and easy input/output data handling.

3.12 ENVI-met Simulation Results Accuracy

ENVI-met Many studies have utilized it to illustrate the accuracy and relevance of their test model, Multiple studies have proved that ENVI-met is effective for modelling the thermal efficiency of outdoor, as demonstrated by Ghaffarian et al.,(2015). The ENVI-met, per the (Lahme et al.,2002), depicted the external world using a restricted range of analytical simulation that could explain dynamic systems. These investigations found that data from local weather stations coincided with modeled air surface temps. Hien et al.,(2006) examined the ENVI-met model, which confirmed the data produced by the field observations. According to (Ozkeresteci et al.2003), a comprehensive investigation was undertaken in longitudinal parks towns in Arizona utilizing ENVI-met modeling trials. According to the findings of this study, ENVI-met may be combined if it is incorporated into the city's data system. Furthermore, they found that by including novel tools such as ENVI-met, urban data systems may function as sustainable ecosystems.

3.13 ENVI-met Work Flow Chart

The process start with (spaces) to draw the model , then put the data base (planet , soil , meterial , ...etc) by using (envi-guide) , by using (envi-core) the simulation will start for 24 hours , the output data can be charts or digrams from (BIO-met) and (lenorado).

As shown in figure below :

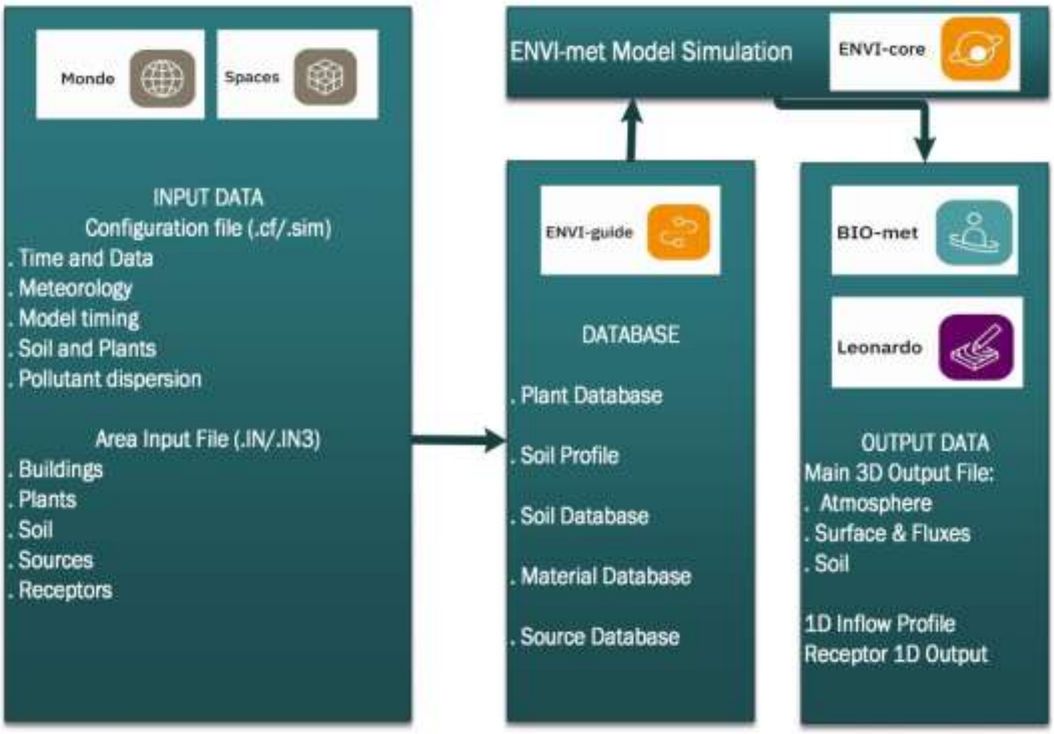

Figure 3.7: ENVI-Met Work Flow Chart

4. METHODOLOGY

4.1 A Micro-Scale Numerical Modeling Solution Based on ENVI-met

The ENVI-met model, as assessed by (Hien et al. 2006), confirmed the results produced by the field observations. According to (Ozkeresteci et al.2003), a descriptive study was done in longitudinal park towns in Arizona utilizing ENVI-met model trials. As a consequence of this research, ENVI-met may be combined if it is incorporated into the city's web application. Furthermore, they found that by including novel technologies like ENVI-met, urban data systems may function as ecological settings.

4.2 Study Area

4.2.1 Introduction

Baghdad is the headquarters and administrative hub of Iraq's Baghdad Province. Its population was over 8.5 million in 2016, making it the biggest metropolis in Baghdad and the 2nd biggest between Arab countries In regards of people, it is rated 40th in the globe. The city is the country's economic, political, and academic hub, as well as its cultural hub.

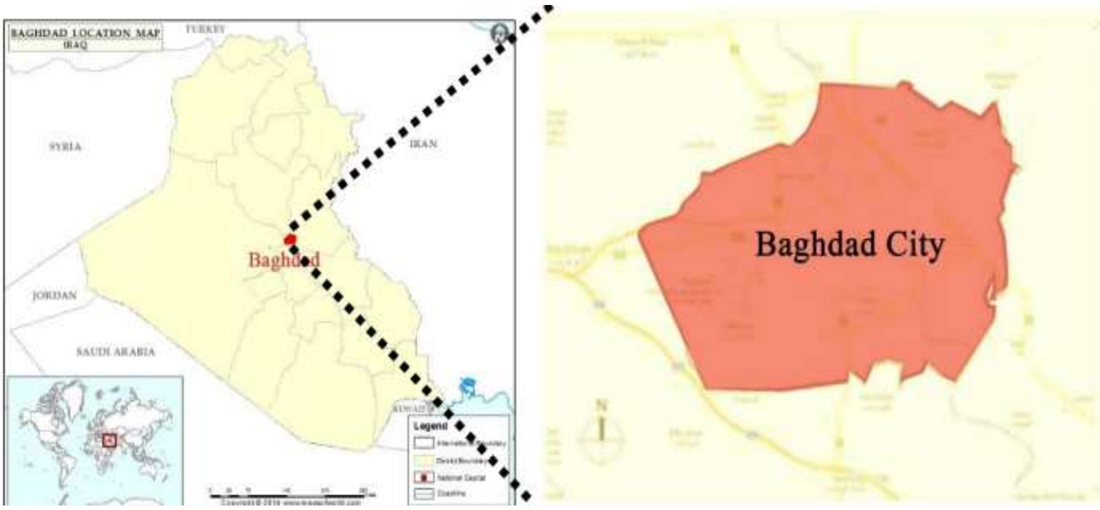

Figure 4.1: location of baghdad on the left & case study on the right

Source: Akbari et al., (2018)

4.2.2 Case Study (Al-Rubaie Street)

It is one of the most famous streets of Baghdad. It is located on the Rusafa side of the city of Baghdad, linking the Karrada neighborhood and Muhammad Al-Qasim highway from the south, and between Palestine Street, the Ministries Complex, and the Army Canal highway from the north. The street contains many commercial buildings in it, such as Al-Ameer Mall, Al-Jawhara Mall and Maxi Mall,It is a five-story marketing center with a high 18 m. In addition to a large group of fashion stores, selling clothes, restaurants, refreshments, and a large number of stores selling mobile devices and accessories. And there are a group of companies, the most important of which is Asia Cell Telecom Company. In addition to a group of entertainment centers, such as Happy Land and Al-Rehana Family Casino, it also contains important mosques such as Al-Qazzaza Mosque, a mosque with a large area. which is shown in figure (4.1) below.

Al-Rubaie Street was built with a length of 1400 m and a width of 44m. It contains pedestrian paths with a width of 7.5 m on each side. A lot of shoppers, merchants, and students take it daily from the early morning hours until midnight. The street does not provide any thermal comfort requirements for pedestrians, such as shading, vegetation, and paving materials that absorb heat and light, which negatively affects the course of business and the economic and social situation of the street. which are shown in figures (4.2) and (4.3).

Figure 4.2: of Alrubaie Street in Bagdad

Source: (earth.google.com)

Figure 4.3: Pedestrian of Alrubaie Street – Left Side

Figure 4.4: Pedestrian of Alrubaie Street – Right Side

4.3 Outdoor Thermal Comfort Definitions

4.3.1 Introduction

The topic of thermal comfort has been discussed since 1930 . Cooling techniques, airflow, absorption, and sun shielding are three critical characteristics that determine the canopy layer climate in dry regions. Sun heating's influence on structures is highly reliant on solar availability. Total solar path penetration is among the most powerful variables influencing climate variables in urban architecture. Parks are often subjected to higher solar radiation than roadways and tractor trailer environments. Controlling solar access consists of two major components: solar accessibility for structures and solar accessibility for walkers.It is possible for solar access to be directly influenced by the amount of solar radiation. As a result, they affect the comfort of outdoor activities. To enhance urban microclimate, solar access is necessary for urban design canyons. It is possible to protect pedestrians from direct sunlight through the use of building components such as arcades, overhangs, canopies, or frames, as well as through the use of trees and vegetation. Adding trees to the pavements or using pedestrian arcades connected to adjacent buildings at street level are two ways to provide shade.

Many studies show that green effects play an important part in the way of ecological chilling of urban planning, as well as in conserving energy and enhancing human thermal comfort. In Cairo, a research was done. Because of the packed shape with nice green islands as well as the air flow thru the main valleys, there were adequate comfort standards and adequate conditioning for various angle of the urban area. Contouring surface help to reduce heat and temperature, which impact thermal comfort at any given time. Shading pavements can release stored energy at night, which might contribute to thermal environment for walkers the following day.

4.3.2 The potential air temperature

The prospective warm air is a little more relevant continuously that the thermometer. Since it is not materially affected by flow through obstructions or huge air disturbance, it raises or lowers in a linear fashion. Whenever there is no warming, chilling, absorption, or precipitation, an air package going over a mountaintop stretches and warms up as it moves up, then contracts and warms as it lowers - but the prospective warmth sometimes doesn't vary (dry adiabatic processes are devoid of these effects). Packages with an electric voltage heat can interchange in spontaneous flow paths without the need for labour or warming.

The symbol is usually used for potential temperatures and the units are degrees C (or F). The numeric difference between in situ and potential temperature is almost always less than ~1.5°C, but it is important to use potential temperature when comparing the temperatures of pedestrians.

In contrast to the thermometer, which might rise or fall, the air quality climate of the environment usually always rises. As a corollary, all dry isothermal operations retain prospective heat, which is critical in the exosphere. (Stewart et al.,2008).

4.3.3 The wind speed

Depending on the speed range of the wind, the air temperature may decrease or increase, resulting in a cooling or heating increase in air temperature when temperatures drop or rise, It may affect a person's comfort or not in either case, and it may also have a moderating effect or not, during which the atmosphere is generally moderate, but in all cases, it depends on the speed of the wind and the temperature recorded during its blow, as well as its source region, which determines its climatic characteristics in general. They are also affected by local factors, such as pressure systems, topographic beams, and others, which affect their movement and characteristics. It is they that control the person's feeling of comfort outside the building, as they control the appreciation of thermal comfort in the absolute air, regardless of the prevailing climatic conditions and clothing (Santamouris, M. 2014).

Due to the diversity of the pressure systems that cause the winds to blow, the winds affect the Iraqi climate in different directions.

Winter northern winds are different from summer northern winds, and the system that causes them to blow during the winter season is different from the system that affects them during the summer. In addition to these types of winds, there are other types of winds that blow throughout the year. It does not only affect its direction but also its speed and accompanying temperature, so different winds will have different effects depending on the season.

A wide range of criteria has been used to study the effects of wind on people's thermal comfort, both locally and globally.

The table below show The average monthly wind speed in Bagdad, Iraq (M/s) over the course of the year.

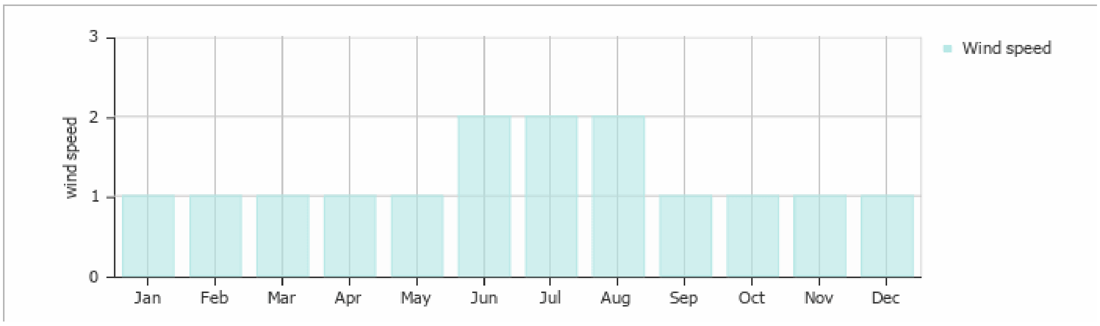

Figure 4.5: Bagdad's Average Wind Speed

Source: Weather-and-climate.com (2022)

4.3.4 Sky view factor and aspect ratio effects (SVF)

A Sky View Factor (SVF) measures the extent to which the sky vault is open (related to diffuse solar and sky components). The value of the factor at a given point ranges between 0 (completely obstructed) and 1. Urban canyon geometry is described by Erell et al., as aspect ratio, also known as height-width. It is calculated as the ratio between the average height of neighboring perpendicular parts, such as building facades, and the average width of a space. As shown in Fig. (4.4). Bakarman et al., (2015) found that surface canyon where H/W =0.42 had higher ambient temperatures during the day compared to deep canyons with H/W =2.2. According to an investigation conducted by Alaoui et al.,2008 an aspect ratio greater than two leads to an increase in energy cooling demand due to the influence of low ventilation and high thermal recession.

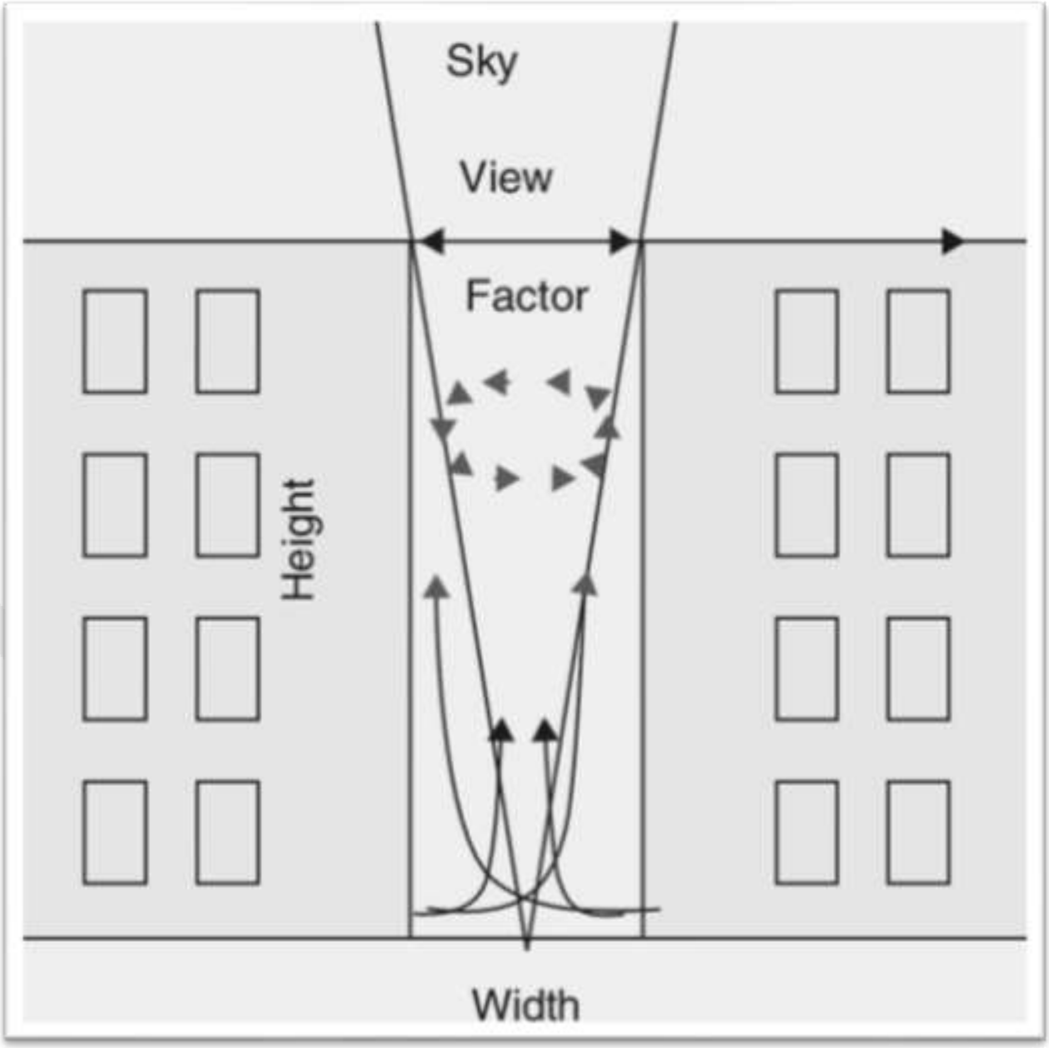

Figure 4.6: Cross-Section of a Symmetrical Pattern of the Canyon

Source: (Jeffrey Raven 2011)

The element size (H / W), which also depicts the canyon's pass ratio, is roughly associated to the sky view factor (SVF). The sky mainly focusing is depicted in Figure (4-5) in connection to the ravine ratio (H/W). According to Brown et al., (2009), when structures block 50% of something like the patch of sky, the sky prominent characteristic is more relevant than 5% since the sky view factor is determined by the predominance of sun energy above the region's surface.

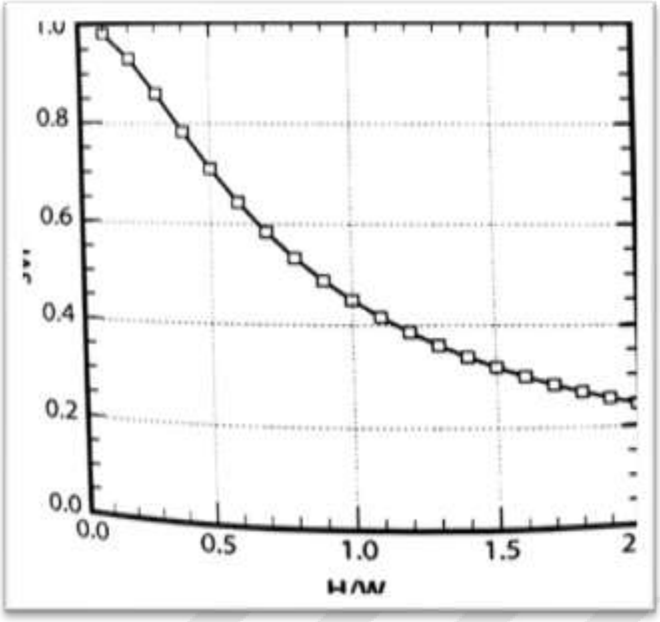

Figure 4.7: SVF in Relation to (H/W)

Source: Williamson et al., (2011)

It has a minor SVF and enhanced photon entrapment due to the concentration of structures in the urban region. As per a comparative evaluation of the ecological conditions of urban open areas in Aleppo's historic region and other modern districts, the influence of shadowing on the Tmrt reduces dramatically as cosmic rays drops in canyons having high SVF (high aspect ratio).

4.3.3 The effect of predicted mean vote (PMV)

The Pmv Vote (PMV) evaluates outdoors thermally comfort using the index, which itself is dependent on heat flux and subjective thermal (Table 4.1). PMV assesses a group's overall thermal sensitivity in their surroundings.

Table 4.1: PMV index

PMV	Value
Cold	-3
Cool	-2
Slightly Cool	-1
Neutral	0
Slightly Warm	+1
Warm	+2
Hot	+3

Source: (ANSI 2004)

Salata et al. discovered that the existence of grass, trees, and bushes in urban areas might diminish the index (PMV) by around 0.5 unit as a result of numerous reflection inside buildings.

4.4 Creating a model

In this work, the researcher impose a 2500 m2 area that represents a specific urban area in Alrubaie street as shown in figures (4.4). The study relies on the advice and findings of earlier surveys and exams to create the space that has been enforced in Baghdad in order to increase the thermal comfort for walkers on the scorching hot days. Furthermore, architectural criteria and standards from Iraq's Ministry of Construction, Infrastructure, and City Services were considered.

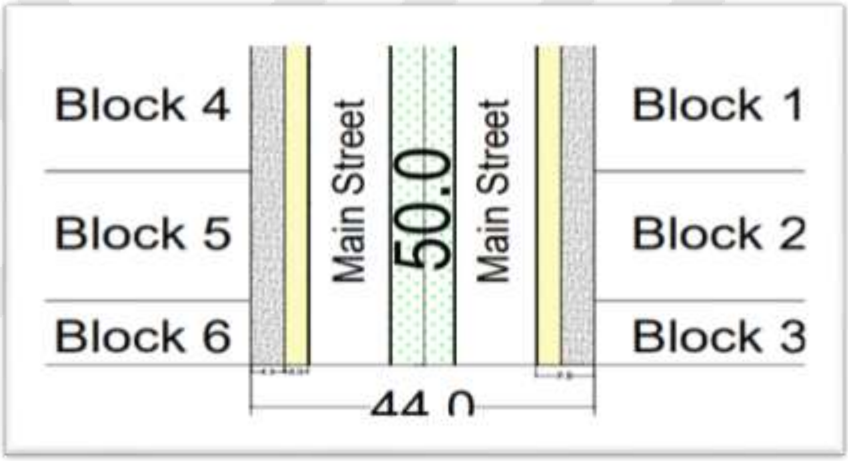

Figure 4.8: Section in Alrubaie Street Drawing by Autocad.

4.5 Methodology

4.5.1 An overview of the proposed model data

Iraqi Meteorological Organization and Seismology provided the data for the proposed model. On the 12th of July, 2010, Baghdad experienced its hottest day of summer with microclimate features. Therefore, the primary conditions had climatology environments of 315 degrees. Wind speed is 5 m/s for direction and 5 m/s for direction. During one day, simple forcing for relative humidity and the air temperature was applied, resulting in a maximum temperature of 50 °C at 4 pm and a minimum temperature of 35 °C at 6 am. At 4 pm, there was a minimum relative humidity of 24%; at 7 am, there was a maximum relative humidity of 36%. There is a 24-hour simulation period. This area has the dimensions of the model (50 x

50)M. Areas for the mode were determined using grid dimensions of x=50, y=50, and z=20. Each grid cell size is dx=2m, dy=2m, and dz=2m. In an arid climate, the model has been rotated based on the buildings' orientations on the actual street.

4.5.2 Alrubaie street model

The residential building heights are 18m (the new requirements for designing residential buildings in Baghdad) with length 50 m , and the orientation is (NE), the researcher put seven receptors on the pedestrians to measure thermal comfort during the day as shown in Fig (4.9).

Figure 4.9: View of Urban Design Model Simulated by ENVI-met

4.5.3 Result analyses for alrubaie street model analysis

The simulation results showed the thermal comfort of the pedestrian paths in Al-Rubaie Street in terms of the air temperature shown in figures (4.9) which ranged between (44-46) degrees Celsius and the wind speed was between (3-5) m/s as shown in the figure (4.10).

Simulation results also showed that (Sky View Factor) ranges between (0.6-0.7) as shown in fig(4.11), and the Predicted Mean Vote above (6) describes as shown in figure (4.12).

The above results represent the lack of sufficient thermal comfort for pedestrians and cause great discomfort to them when using it in the daytime especially.

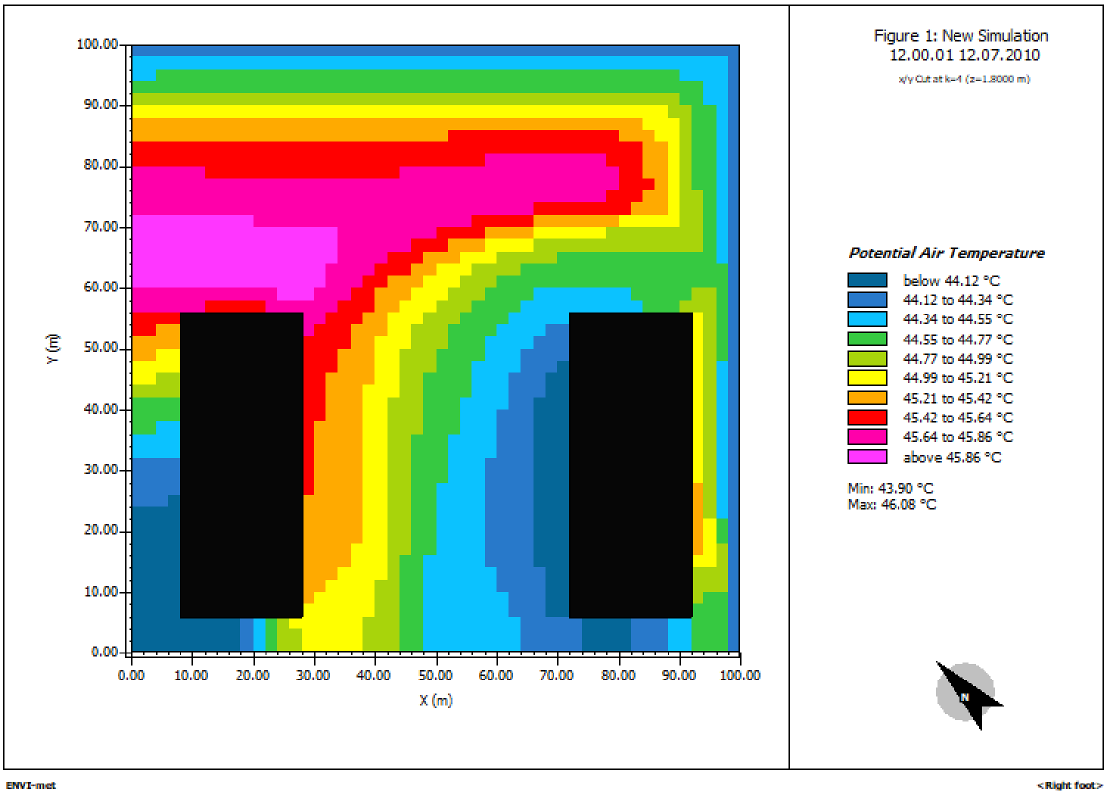

Figure 4.10: Potential Air Temperature for Alrubaie Street Model Simulated by ENVI-met.

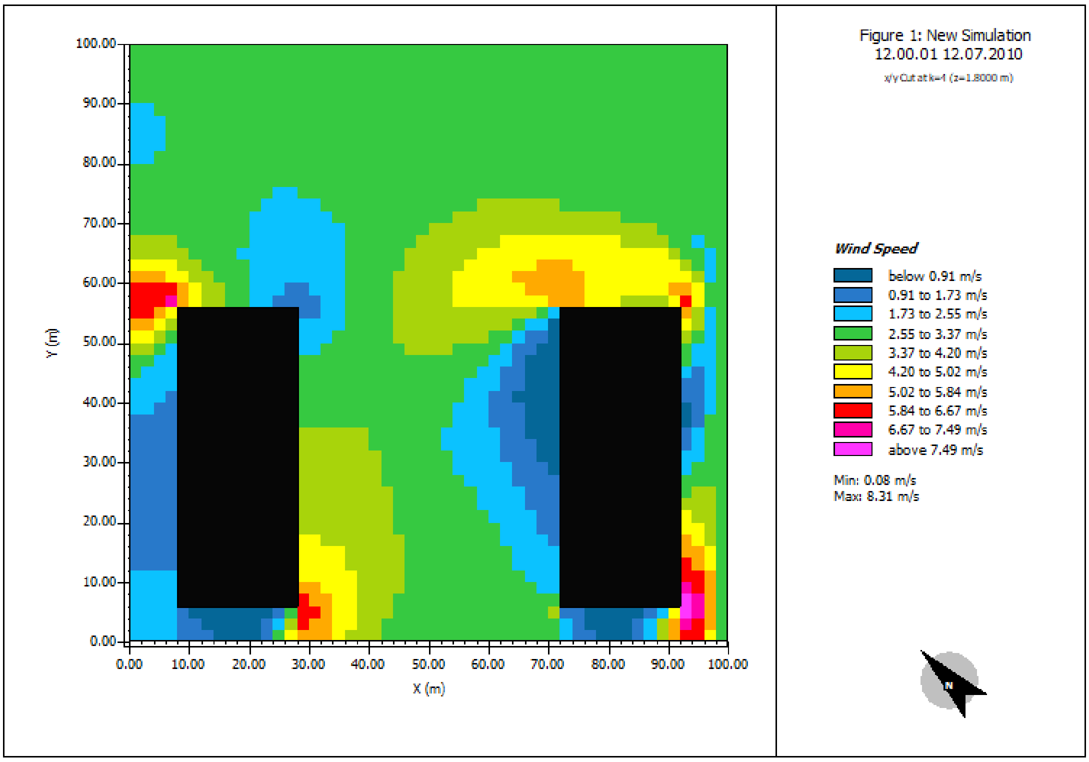

Figure 4.11: Wind Speed for Alrubaie Street Model Simulated by ENVI-met

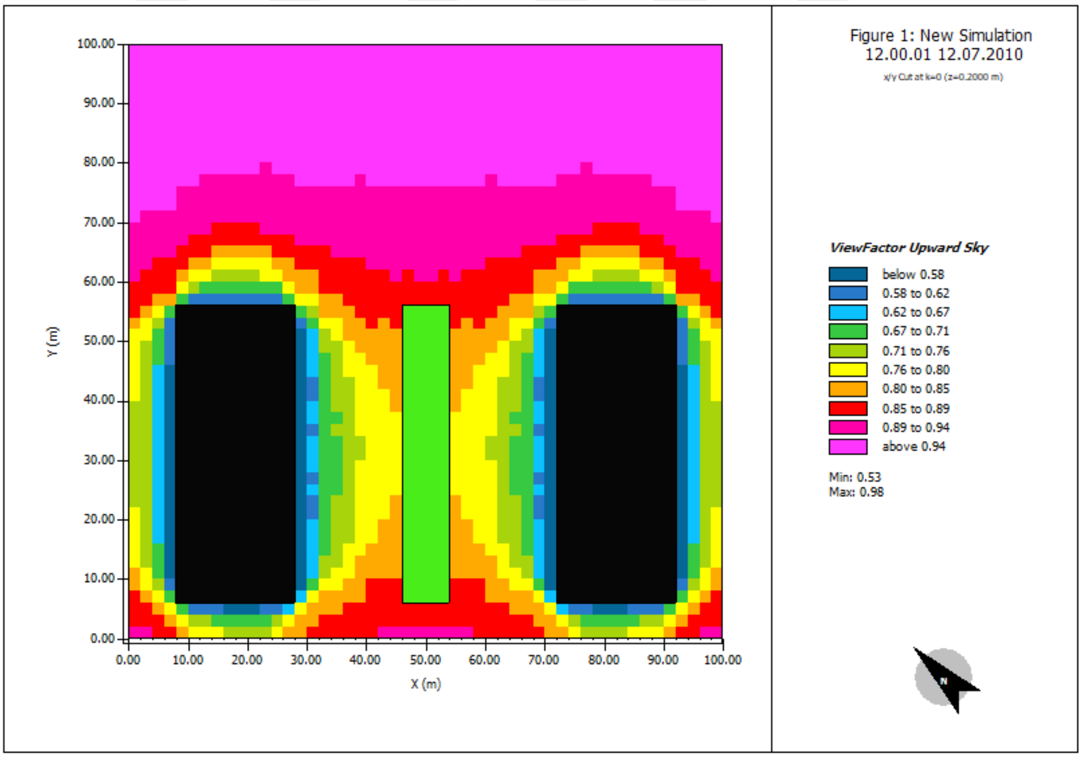

Figure 4.12: SVF for Alrubaie Street Model Simulated by ENVI-met

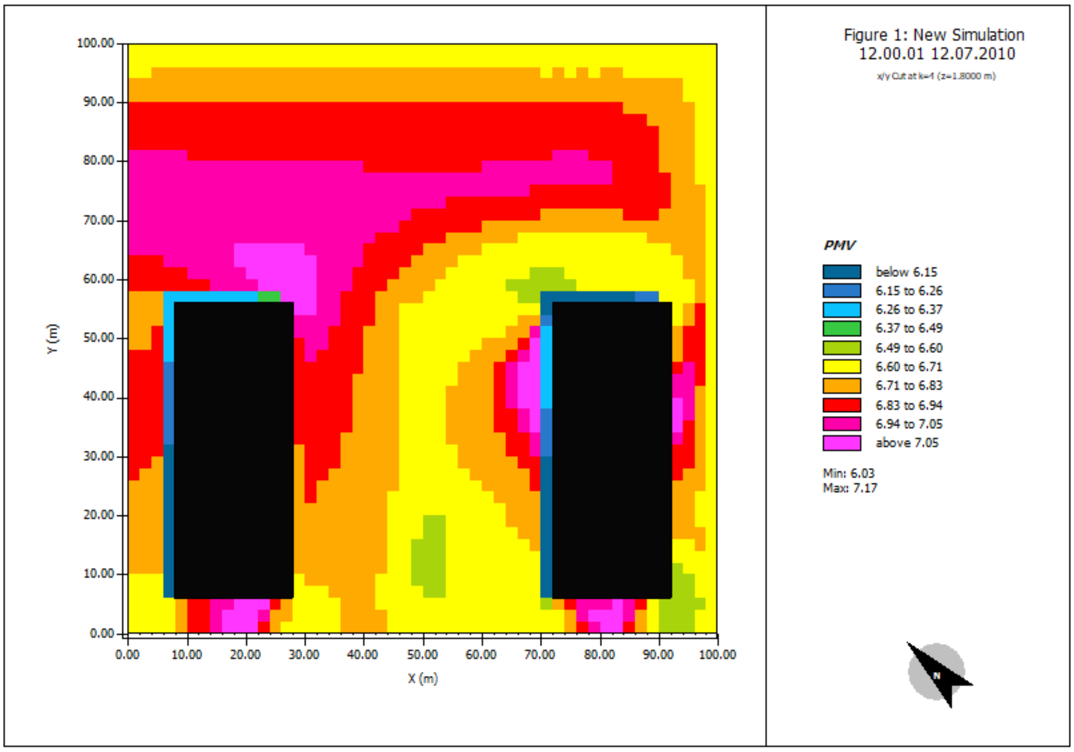

Figure 4.13: PMV for Model Simulated by ENVI-met

4.6 Developing Alrubaie Street

In order to provide thermal comfort for pedestrians and increase the number of road pedestrians during the hot daylight hours, the researcher suggested developing Al Rubie Street and improving pedestrian corridors at the lowest cost while increasing the aesthetics of the street and preserving the urban design of the city.

Concerning the role of albedo in enhancing outdoor thermal comfort, the researcher chose granite pavement for pedestrians and keep the asphalt road.

In order to enhance the active role of shading, which mainly affects the thermal comfort of pedestrians, the researcher suggested placing vegetation cover using the Albizia tree in order to take advantage of the amount of shade that the trees contribute to each other to protect pedestrians as shown in figure (4.13).

Figure 4.14: The suggested design for developing the street

Source: Ankara (2022)

4.6.1 Specifications of granite used in street development

This rock is one of the igneous rocks spread out on the earth's crust, and it takes many colors, such as gray and pink, but it is not called granite marble, which indicates its hardness and distinction from other types of rocks.

- The durability of granite makes it an ideal rock for a wide range of applications

The material is considered one of the best materials for preventing water leakage.

- A granite surface does not have a shiny finish, so it is easy to maintain.
- It is a hard rock that will last for a long time without getting damaged.
- The presence of stains won't affect it so long as it is closed.
- It is one of the materials that can withstand very high temperatures.

4.6.2 Albizia tree specifications

A tree that grows in temperate and tropical climates. This plant is a member of the leguminous family Albizia. It is a fast-growing, dense tree. It has a diameter of 10-15 meters and a height of 5-15 meters. It originated in Southeast Asia, India, and China. It grows best in light, fertile soil, but it can also grow in poor soil.

This tree is known for its ability to moisturize the atmosphere, reduce heat, and provide dark shades underneath, and it is also used as a sedative to reduce stress and anxiety for those suffering from chronic stress hormones as show in figure (4.14).

Figure 4.15: Albizia Tree

Source: Baghdad (2022)

4.7 Al-Rubie Street model after development

In this work, an area of 2500 square meters represents a specific urban area in Baghdad. In order to improve the outdoor thermal comfort for pedestrians in Baghdad during the hottest summer days, the researcher relied on recommendations and results of prior research and studies. Furthermore, building specifications and building requirements were derived from the Ministry of Construction, Housing and Public Works in Iraq. Based on the following principles, the proposed model for the proposed urban area was developed:

1- The researcher raised the pedestrian sidewalk consisting of concrete and interlock and placed the pieces of the granite shown below figure (4.15) in the grey color:

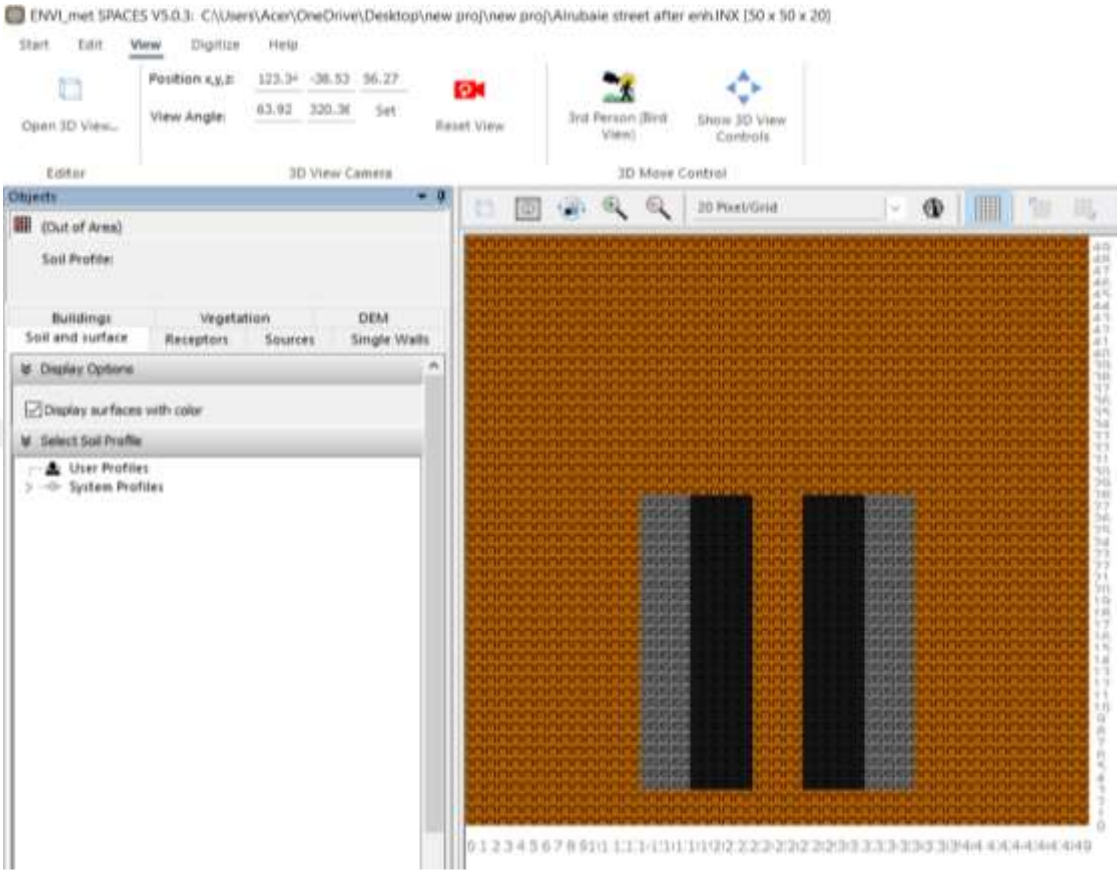

Figure 4.16: View of the Developed Urban Design (soil & surface) Simulated by ENVI-met.

2- The researcher placed Albizia trees every 10 meters, as shown in the figure (4.16) below:

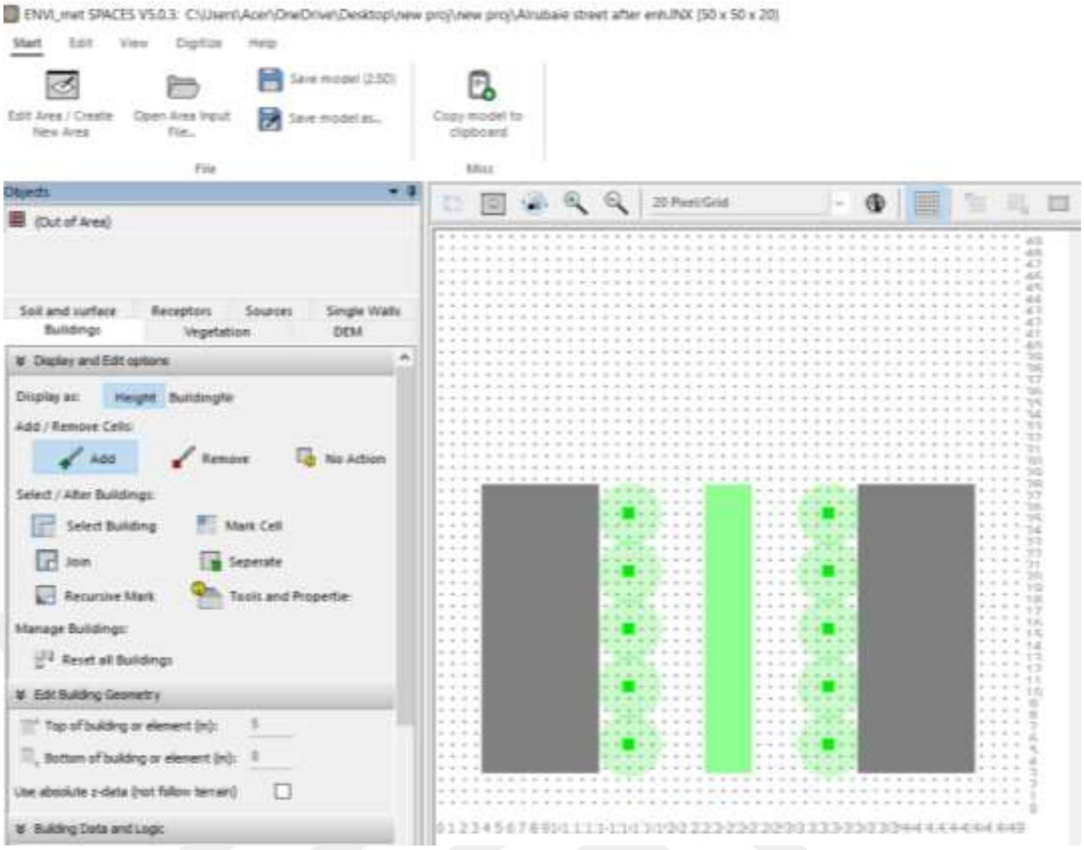

Figure 4.17: View of the Developed Urban Design (vegetation) Simulated by ENVI-met

3. The 3D model will be as below:

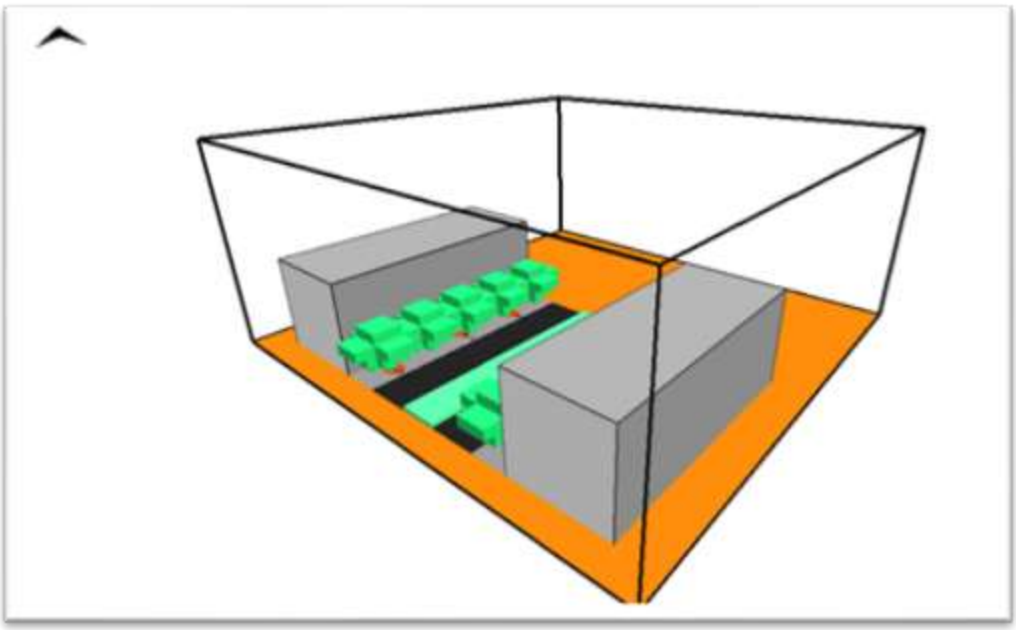

Figure 4.18: View of 3D Developed Model Simulated by ENVI-met.

4.8 Results Analysis for the developed model

This study focuses on relieving heat stress during the long summer in Baghdad by suggesting a new design for sustainable streets with different design patterns. The simulation results proved that the diversity of climate variables is important in terms of wind speed, air temperature, Sky View Factor, and Predicted Mean Vote. The study aims to design buildings of equal heights, reduce large areas between them, perpetuate and afforestation of arid lands, and create industrial thermal comfort.
The results of the simulation of air temperature, wind speed, Sky View Factor, and average Predicted Mean Vote in Figure (4.18) and the results of Figure (4.19), Figure (4.20), and Figure (4.21) showed that a significant decrease of 5 degrees Celsius in air temperature significantly outside the construction buildings and on air corridors and courtyards and pedestrians and increase the external thermal comfort for road pedestrians.

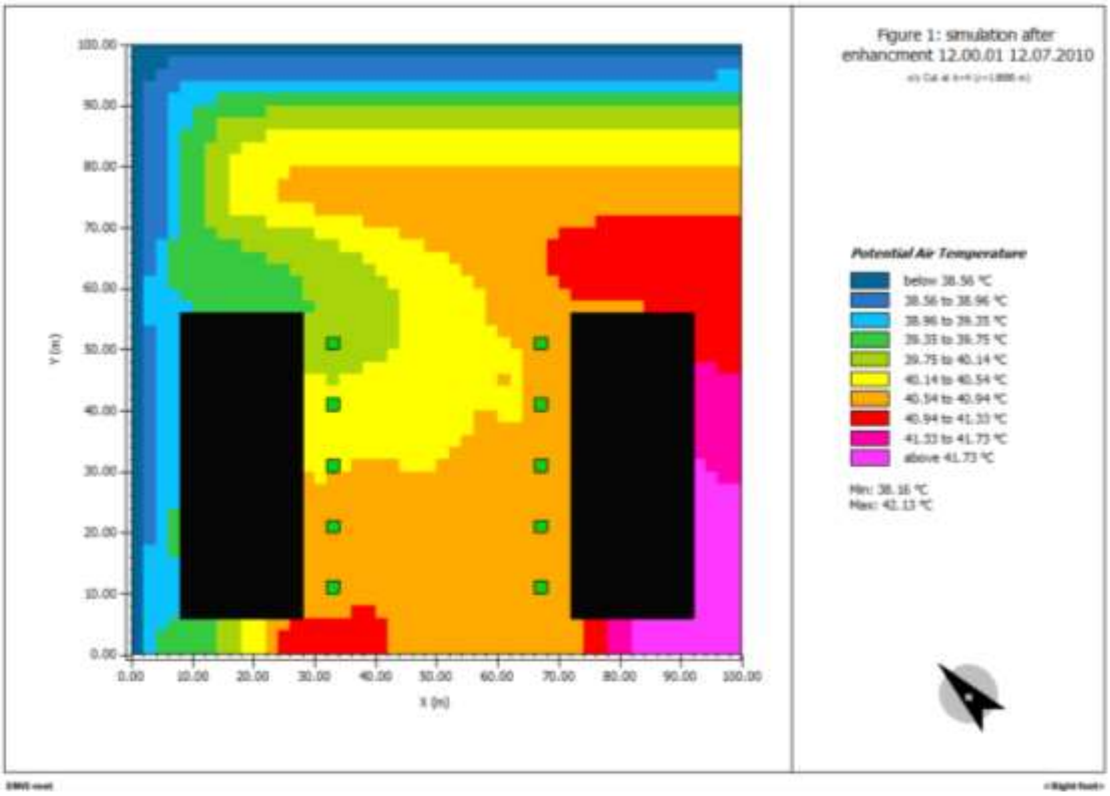

Figure 4.19: Potential Air Temperature for Developed Model Simulated by ENVI-met

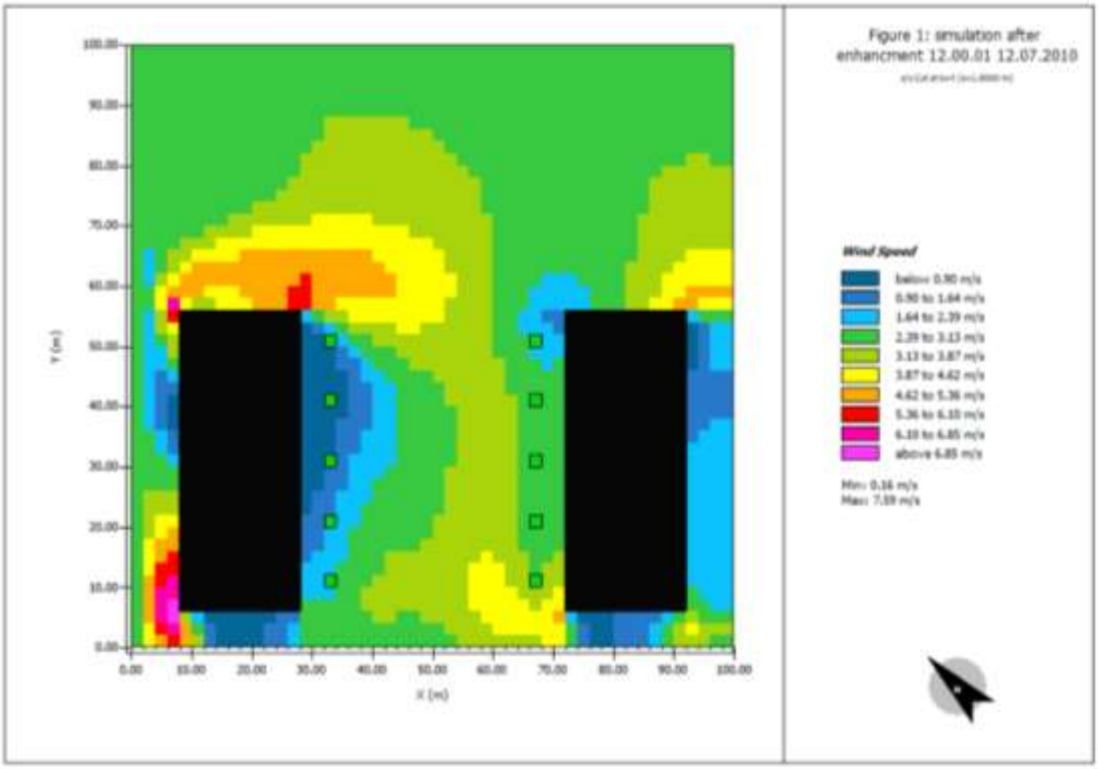

Figure 4.20: Wind Speed for Developed Model Simulated by ENVI-met

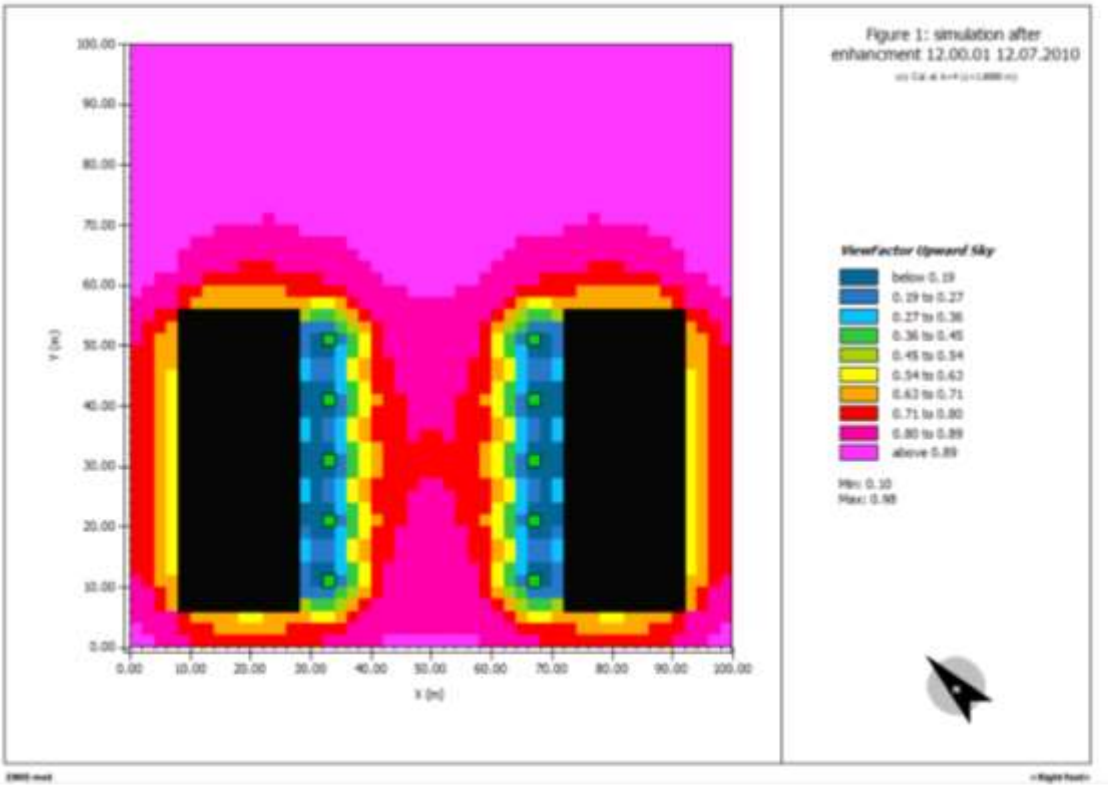

Figure 4.21: SVF for Developed Model Simulated by ENVI-met

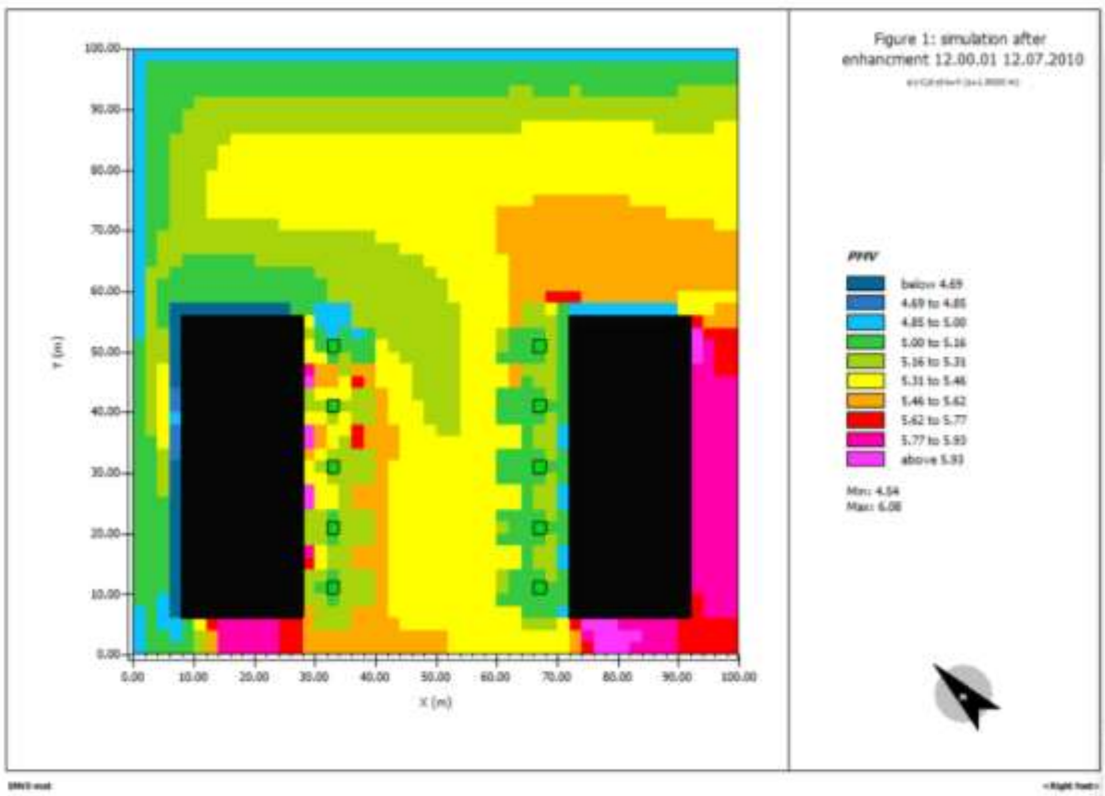

Figure 4.22: PMV for Developed Model Simulated by ENVI-met

4.9 The Summary

The methodology used in generating the physical and spatial characteristics of virtual urban environments, as well as the microclimate models used, along with their relevance to the subject of study, as well as external thermal comfort for pedestrians, were presented in this chapter.

A flowchart below shows the results of the local climate modeling and evaluation of external thermal comfort in the proposed urban settings, as well as the method of analysis of the simulation results to arrive at the best thermal comfort:

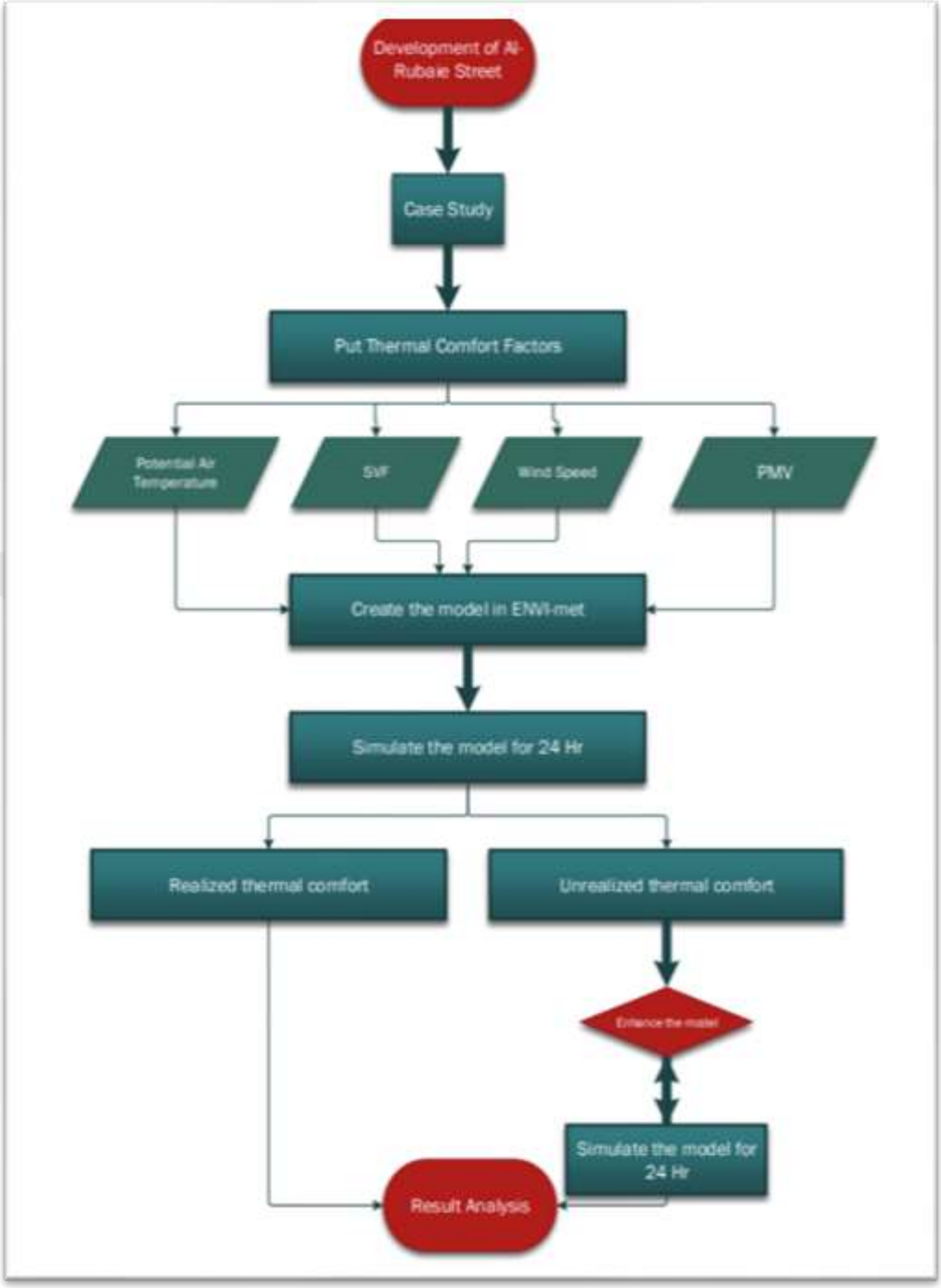

Figure 4.23: Methodology Flow Chart

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

Its most control factors in assessing thermal comfort were identified through a survey of the material. First, the study fields from whom the investigations were connected were found by analyzing and characterizing the authors' phrases. Included these were largely quality criteria for outdoors, behavioural factors, and computer algorithms for more precise thermal comfort.

Moreover, the UHI phenomena, including its origins and effects, are widely established in the research, including the impact on human wellness and thermal comfort, maximum cooling energy use, air pollution, and surface water deterioration. Pavements, highways, and car parks, for example, cover a considerable part of urban surfaces and hence play an essential role in the production of UHI.

Morether , these variables could be classified and then linked to the capture devices. Environmental variables can be measured using devices that are standardized to achieve greater accuracy in the measurements. Height, data collection intervals, position close to the user, and proximity to other thermal devices were found to be important factors to consider. In terms of co-occurrence analysis, the most influential variables were discovered to be potential air temperature, airspeed, Sky View Factor, and Predicted Mean Vote. Furthermore, metabolic rate and clothing insulation provide physiological variables.

Based on the results of this study, the following conclusions can be drawn:

1- in Alrubaie street: lack of vegetation, shadows, and distance between buildings lead to increased absorption and release of heat during the daytime on the surfaces of buildings and ground. The Urban Heat Island can be caused by all of these factors.

2- In a hot, arid climate, the mean radiant temperature appears to be impacted largely by urban configuration, sky view factor, light patterning, and inner passageway width among structures These factors impact microclimate settings and outdoors thermal comfort.

3- In hot and dry areas, buildings play a vital role: using a thick, matt quartz flooring helps delay and limit heat absorption from the heated exterior to the inside and gives a comparatively cool floor during the day in summer.

4- Vegetation has the greatest impact throughout hot humid day circumstances. The resultant gradients play a vital role in increasing thermal comfort.

5- The Developed model described in Chapter 4 of about the thesis looks to give improved thermal settings about 5 ℃ due to the influence of shadows and plants.

5.2 Recommendatıons

- ✓ The need to intensify shaded green areas in open areas and pedestrian paths located in a hot and dry climate.
- ✓ It is necessary for planners to use afforestation within street buildings for its great role in reducing the temperature of pedestrian sidewalks and improving the sense of visual and thermal comfort for users.
- ✓ The need for planners to use vegetation inside the streets for its great role in reducing the temperature of pedestrian sidewalks and improving the sense of visual and thermal comfort for users.
- ✓ The need for those concerned to use the types of trees that provide dark shades in the summer and allow part of the sun's rays to pass through during the winter season.
- ✓ The importance of simulating the thermal performance of open spaces in public places, recreational areas, and pedestrian paths in the initial stages of design using programs such as ENVI-met, which allows evaluation of the environmental design criteria used in the project.
- ✓ Air movement in public spaces, including squares, gardens, and pedestrian paths, is meant to be studied in the early stages of design, in order to simulate air movement at a stage where the designer can improve the design of the

landscape and the site. Coordination within the project without additional costs.

- ✓ The necessity of having legislation limiting a certain percentage of shading inside the open paths to provide thermal comfort for pedestrians in Iraq.

5.3 Future Works

In order to develop this thesis in the future, the researcher suggests developing the types of asphalt and its colors used in the streets, which affects the thermal comfort of pedestrians, as well as the use of types of industrial shading using low-cost sheds which the time of their construction is fast, In addition, green walls can be used to reduce sunlight reflections on pedestrians.

REFRENCES

A.Matzarakis, F. Rutz, and H. Mayer (2007) Modelling radiation fluxes in simple and complex environments - application of the Rayman model. International Journal of Biometeorology, 51:323–334.

Akbari H., Levinson R., and Rainer L.,(2005) Monitoring the Energy-use Effects of Cool Roofs on California Commercial Buildings, Energy and Buildings 37 -1007- 1016.

Akbari H., Matthews H., (2012)Global Cooling Updates: Reflective Roofs and Pavements, Energy and Buildings 55 - 2-6.

Arnfield A., J., (1991)Street Design and Urban Canyon Solar Access. Energy and Buildings 14 - 117-131.

Bakarman M. and Chang J., (2015)The Influence of Height/Width Ratio on Urban Heat Island in Hot-Arid Climates. Procedia Engineering 118 ,101-108.

Becker, Givoni, B., M. Noguchi, H. Saaroni, O. Pochter, Y. Yaacov, N. Feller and S. (2003). "Outdoor Comfort Research Issues." Energy and Buildings.

Bouyer J., Musy M., Huang Y., and Athamena K., (2009). Mitigating Urban Heat Island Effect by Urban Design: Forms and Materials, Fifth Urban Research Symposium.

Bowler, D. E., L. Buyung-Ali, T. M. Knight, and A. S. Pullin (2010) "Urban greening to cool towns and cities: A systematic review of the empirical evidence." Landscape Urban Plan. 97 (3): 147–155. https://doi.org/10 .1016/j.landurbplan.2010.05.006.

Brazel A., Hedquist B., Sabatino S., Fernado H., Leo L., (2009)Results from the Phoenix Arizona Urban Heat Island Experiment. The Seventh International conference on Urban climate Yokohama, Japan.

Bruse M. and Fleer H., (1998)Simulating Surface- Plant – Air Interactions Inside Urban Environments with a Three Dimensional Numerical Model. Environmental Modeling and Software 13 (1998) 373-384.

Chen L., and Ng E., A., (2009)Sky View Factor Analysis of Street Canyons and Its Implication for Urban Heat Island Intensity, 26th Conference on Passive and Low Energy Architecture, Quebec City, Canada 22-24.

Chen L., Ng E., An X., Ren C., Lee M., Wang U., and He Z.,(2012) Sky View Factor Analysis of Street Canyons and its Implications for Daytime Intra-Urban Air Temperature Differentials in High-Rise, High-Density Urban Areas of Hong Kong: a GIS-Based Simulation Approach. International Journal of Climatology 32 ,121-136.

Chen Y., Lin T., Matzarakis A., (2014)Comparison of Mean Radiant Temperature from Field Experiment and Modelling: A Case Study in Freiburg, Germany, Theoretical and Applied Climatology 535-551.

Damour, G. T., Simonneau, T., Cochard, H.,(2013) and Urban, L. An overview of models of stomatal conductance at the leaf level. Plant, Cell and Environment, 33:1419– 1438.

Deilami, K.; Kamruzzaman, M.; Liu, Y.(2018), Urban heat island effect: A systematic review of Spatio-temporal factors, data, methods, and mitigation measures. Int. J. Appl. Earth Obs. Geoinf. 67, 30–42.

Dorer V., Allegrini J., Kämpf J. and Carmeliet J., .,(2013) ., Modelling the Urban Microclimate and its influence on Building Energy Demands of an Urban Neighborhood. CISBAT Lausanne, Switzerland .

EC2 (2002), Urban Heat Island Mitigation Strategy Toolkit , Ryerson School of Urban and Regional Planning 105 Bond Street #400 Toronto, ON M5B 2K3.

Elsayed I., (2012) Mitigation of the Urban Heat Island of the City of Kuala Lumpur, Malaysia. Middle-East Journal of Scientific Research 11- 1602-1613.

F. Lindberg, B. Holmer, and S. Thorsson. Solweig (2008), modeling spatial variations of 3d radiant fluxes and mean radiant temperature in complex urban settings. International Journal of Biometeorology, 52:697–713.ISSN 0020-7128.

Fahmy M., A., R., (2010). Interactive Urban Form Design of Local Climate Scale in Hot Semi-Arid Zone, Ph.D. thesis, The University of Sheffield School of Architecture, UK.

Feyisa, G.L., Meilby, H., Fensholt, R. and Proud, S.R. (2014) Automated Water Extraction Index: A New Technique for Surface Water Mapping Using Landsat Imagery. Remote Sensing of Environment, 140, 23-35. http://dx.doi.org/10.1016/j.rse.2013.08.029.

Ghaffarian hoseini A., Berardi U., and Ghaffarianhoseini A., (2015) Thermal Performance Characteristics of Unshaded Courtyards in Hot and Humid Climates. Building and Environment.

Global Cool Cities Alliance, (2012) A Practical Guide to Cool Roofs and Cool Pavements

Grados, A.; Royon, L., **Hendel, M.; Parison, S. (2018);** Which pavement structures are best suited to limiting the UHI effect? A laboratory-scale study of Parisian pavement structures. Build. Environ. 144, 216–229.

Haddad, B.; Karaky, H.; Sebaibi, N.; Boutouil, M.; Vujovic; (2021) Urban Heat Island: Causes, Consequences, and Mitigation Measures with Emphasis on Reflective and Permeable Pavements. CivilEng, 2, 459–484. https://doi.org/10.3390/civileng20200.

Hedquist B., Sabatino S., Fernado H., Leo L., Brazel A., (2009)Results from the Phoenix Arizona Urban Heat Island Experiment. The Seventh International conference on Urban climate Yokohama, Japan .

Helge Simon (2016) Modeling urban microclimate Development, implementation, and evaluation of new and improved calculation methods for the urban microclimate model ENVI-met, Department of Geography, Johannes Gutenberg University Mainz, 55099 Mainz, Germany

Hien w., Yu Ch., (2006)Thermal benefits of city parks. Energy and Buildings 38.

Hove L., Steeneveld G., Jacobs C., Heusinkveld B., Elbers J., Moors E., and Holtslag A., (2011) Exploring the Urban Heat Island Intensity of Dutch cities, Alterra part of Wageningen UR Wageningen.

Huttner S., (2012)Further Development and Application of the 3D Microclimate Simulation Envi-met. PhD Thesis, Mainz, Germany.

Huttner S., Bruse M., Dostal P.,(2008) Using ENVI-met to simulate the Impact of Global Warming on the Microclimate in Central European Cities. 5th Japanese-German Meeting on Urban Climatology, 307-312.

Idczak M., Groleau D., Mestayer P., Michel Rosant J., and François Sini J., (2010)An Application of the Thermo-Radiative Model SOLENE for the Evaluation of Street Canyon Energy Balance. Building and Environment 45,1262-1275.

J. Eichhorn. Entwicklung und Anwendung eines dreidimensionalen mikroskaligen Stadtklima-Modells. PhD thesis, Univ. Mainz, 1989. URL http://www.staff. uni-mainz.de/eichhorn/docs/diss_eichhorn_1989. PDF Retrieved 20.02.2011

Jeffrey Raven (2011) Cooling the Public Realm: Climate-Resilient Urban Design , Sustainability + Planning + Urban Design + Architecture, 15 Charles Street, 5a, New York, NY 10014, USA.

Jendritzky G., Kampmann B., Richards M., Rintamaki H., Shitzer A., and Havenith G., Brode P., Fiala D., Blazejczyk K., Epstein Y., Holmer I., (2009)Calculating UTCI Equivalent Temperature, Poster presentation at the 13th International Conference on Environmental Ergonomic, Boston, Massachusetts, USA.

Katul G., Mahrt L., Poggi D., and Sanz C., (2003)One and Two Equation Models for Canopy Turbulence. Nicholas School of the Environment and Earth Sciences, Duke University, Durham.

Lahme E. and Bruse M., (2002)Microclimatic effects of a small urban park in densely built–up areas: Measurements and model simulations. The European Commission in the 5th Framework Program under the contract.

Lemonsu A., Masson V., (2002)Simulation of a Summer Urban Breeze over Paris. Boundary-Layer Meteorology 104 , 463-490.

Li H., (2012), Evaluation of Cool Pavement Strategies for Heat Island Mitigation Improving Outdoor Thermal Environment in Hot Climates through Cool Pavement DesignStrategies, Ph.D. Thesis, Civil and Environmental Engineering, University of California.

Matzarakis A., Rutz F.,(2007) and Mayer H., Modelling Radiation Fluxes in Simple and complex Environment-Application of the Ray Man Model, International Journal Biometeorology 51 323-334.

Mayer H., **Ali-Toudert F.**,(2006) Numerical Study on the Effects of Aspect Ratio and Orientation of an Urban Street Canyon on Outdoor Thermal Comfort in Hot and Dry Climate, Building and Environment 41 - 94-108.

McGraw-Hill (2003)"Dictionary of Architecture and Construction". Copyright © 2003 by McGraw-Hill Companies, Inc.

Mellor G and Yamada T.,(1975) A Simulation of Wangara Atmospheric Boundary Layer Data. Journal of Atmospheric sciences 32 .

Mitković1 , Milena M. Dinić Branković1 , Milica Z. Igić1 , Petar S. Đekić2 , Mihailo P. Mitković1 (2015) The Study Of Effects Of Greenery On Temperature Reduction In Urban Areas , 1University of Niš Faculty of Civil Engineering and Architecture, Niš, Serbia

Monam A., Ruckert K., (2013)The Dependence of Outdoor Thermal Comfort on Urban Layouts, German-Iranian Research Project. Young Cities. Developing Energy-Efficient Urban Fabric in the Tehran-Karaji Region

Monteiro, Phillip Handley, James I. L . Morison and Kieron J. Doick (2019) The role of urban trees and greenspaces in reducing urban air temperatures, Forest Research Alice Holt Lodge Farnham Surrey, GU10 4LH (www.forestry.gov.uk/forestresearch)

Nacion Rotonda (2021) The influence of vegetation on thermal comfort for the microclimatic condition of Vitória Planning and Projects Laboratory , https://lpp.ufes.br/influ%C3%AAncia-da-vegeta%C3%A7%C3%A3o-no-conforto-t%C3%A9rmico-para-condi%C3%A7%C3%A3o-microclim%C3%A1tica-de-vit%C3%B3ria-es.

Norford, L.K.; Britter, R., (2009)An Urban Weather Generator Coupling Building Simulations with a Physically Based Urban Model. In Proceedings of the 7th Internation Conference on Urban Climate (ICUC-7), Yokohama, Japan.

Norton, B. A., Coutts, A. M., Livesley, S. J., Harris, R. J., Hunter, A. M., and Williams, N. S. G. (2015) Planning for Cooler Cities: A Framework to Prioritise Green Infrastructure to Mitigate High Temperatures in Urban Landscapes. Landscape and Urban Planning 134 127-138.

Nuruzzaman, M.(2016) Urban Heat Island: Causes, Effects and Mitigation Measures—A Review. Int. J. Environ. Monit. Anal. 3, 67–73.

Oke T., Johnson G., T., Steyn D., G., Watson I., D., (1991)Simulation of Surface Urban Heat Islands Under Ideal Conditions at Night Part 2 Diagnosis of Causation 56 - 275- 294.

Oke T., Lyons T., Steyn D., Watson I., and Voogt J.,(1991) Simulation of Surface Urban Heat Islands Under Ideal Conditions Journal at Night Part 1: Theory and Tests Against Field Data. Boundary-Layer Meteorology 56 - 275-294.

Oke T., R., Thermal Remote Sensing of Urban Climates, Journal of Remote Sensing of Environment 86 (2003) 370-384

Oke T.,(1999) Scale modeling of nocturnal cooling in urban parks. Boundary-Layer Meteorology 93 287-312

Oke, T., (1988) Street Design and Urban Canopy Layer Climate, Energy and Buildings 11103-113.

R. Macdonald, **Robins.,** (1999) "Review of Flow and Dispersion in the Vicinity of Buildings," Atmospheric Dispersion Modeling Liaison Committee Annual Report

Rizwan, A.M., Dennis, Y.C.L. and Liu, C. (2008). A review of the generation, determination, and mitigation of Urban Heat Island. Journal of Environmental Sciences 20, 120–128.

Sailor J., D., (1995) Simulated Urban Climate Response to Modifications in Surface Albedo and Vegetation Cover, Journal of Applied Meteorology 1694-1704

Salata F., Gllasi I., Vollaro E., L., Bisegna F., Nardecchia F., Coppi M., Gugliermetti F., Vollaro A., L., (2015) Evaluation of Different Urban Microclimate Mitigation Strategies through a PMV Analysis, Sustainability 7,9012-9030

Santamouris M., (2014) Using Cool Pavements as a Mitigation Strategy to Fight Urban Heat Island-A review of the Actual Developments. Renewable and Sustainable Energy Reviews.

Shishegar N., (2013)Street Design and Urban Microclimate: Analyzing the Effects of Street Geometry and Orientation on Airflow and Solar Access in Urban Canyons. Journal of Clean Energy Technologies 1 - 52-56.

Stewart, Robert H. (September 2008). "6.5: Density, Potential Temperature, and Neutral Density".Introduction To Physical Oceanography)

Swaid H., Bar-El M., and Hoffman M., (1993) A Bioclimatic Design Methodology for Urban Outdoor Spaces. Theoretical and Applied Climatology 48,49-61.

Taha H.,(1999) Konopacki St., Gabersek S., Impact of Large–Scale Surface Modifications on Meteorological Conditions and Energy Use, A 10 – Region Modeling Study, Theoretical and Applied Climatology 175-185.

U. Sievers. (1995) Verallgemeinerung der stromfunktionsmethode auf drei dimensionen. Meteorologische Zeitschrift, 4:3–15.

Wang Y. and Akbari H., (2016) The Effect of Street Tree Planting on Urban Heat Island Mitigation in Montreal. Sustainable Cities and Society 27 122-128

Wang, X., Mao, D., Yu, W., Jiang, Z., (2015). The acoustic performance of balconies having inhomogeneous ceiling surfaces on a roadside building facade. Build. Environ. 93 (P2), 1–8. https://doi.org/10.1016/j.buildenv.2015.06.027

Williamson T., Erell E., Pearlmutter D., (2011) Urban Microclimate Designing the Spaces between Buildings, New York .

Wong H., N., Yu Ch., (2005)Study of Green Areas and Urban Heat Island in a Tropical City, Journal of Habitat International 29 -547-558.

Y. Mahrer and R. Avissar(1984) A numerical simulation of the greenhouse microclimate. Mathematics and Computers in Simulation, 26(3):218 – 228.

Yang J., Wong M., S., Menenti M., and Nichol J., (2015)Modeling the Effective Emissive of the Urban Canopy Using Sky View Factor, ISPRS Journal of Photogrammetry and Remote Sensing 105 , 211-219.

Yang X., Zhao L., Bruse M., Meng Q., (2012)An integrated Simulation Method for Building Energy Performance Assessment in Urban Environments. Energy and Buildings 243-251.

Zhang, X., (2011) Research on Heat Reflection and Thermal Resistance Technology of Asphalt Pavement Cooling Mechanism and Its Application, in School of Transportation Science and Engineering (Ph.D. thesis), Institute of Technology: Harbin, China. p. 127.

RESUME

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