

Building Height as a Tool for Environmental Urban Control

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Abstract: Environment affects the life of residents in terms of their physical and mental health. Many studies have shown that building design elements affect the urban thermal environment.

Building regulations: setbacks, building height and building footprints, strongly influence urban form. Consequently, urban planning regulations have a great impact on the urban microclimate.

The geometric form of the urban canopy layer greatly influences the urban climate, while climate-conscious urban planning and design in developing countries is scarce. By increasing urban densification, a strategic development framework is required for sustainable developments, which among others ensures a thermally desirable microclimate.

This study, tries to link field measurements and simulations of the urban microclimate in residential areas in Amman city, as affected by the relationship between building height and urban regulation in one selected study area, by using ENVI- met program to simulate Air temperature, Radiant temperature and Relative humidity.

The research concluded that by decreasing the height of residential buildings a decrease in air temperature and mean radiant temperature would occur due to the increased percentage of shaded areas.

Keywords : Thermal comfort ; urban microclimate; urban heat island; Radiant temperature; Amman.

Introduction

Due to the complexity of the outdoor environment, urban design patterns considerably affect the microclimate and outdoor thermal comfort in a given urban morphology. Parameters such as building height and orientation, spaces between buildings, plot coverage, etc influence the microclimate in terms of solar access, shade, wind speed and direction. In developing countries, increasing urbanization has become a problem that affects the urban environment and lead to a poor urban health. (Yahya M. W., Johansson E ,2015).

Many leisure and recreational activities are conducted in outdoor environments, exposing participants directly to the weather. Several studies conducted in a wide range of climate zones have indicated that the number of individuals who use outdoor spaces is related to air temperature (Ta), mean radiant temperature (Tmrt) and other thermal comfort indices(Tzu-Ping Lin, Richard de Dearband Ruey-Lung Hwangc 2010, Effect of thermal adaptation on seasonal outdoor thermal comfort. (Karyono TH., 1998).

The building configuration may be such that they shade each other mutually. The amount and effectiveness of the shading, however, depends on the type of building clusters . Detached buildings

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and those at the end of a row of buildings or similarly positioned flats in multi-story buildings, that have more than one external wall, will obviously have greater heat gain and losses than those with only one external wall. The building designer should keep in mind that building with more than one external wall should not be confronted in the same way from an energy saving point of view as buildings with two or more external walls. Surfaces that are in direct contact with the external environment may require insulation. (Ghaddar, et al 2011)

The planning strategies and processes, during the urbanization process, are often more focused on subdivision of land, building roads and some necessities but urban irrigation is something that is added at the end. There is a need for holistic thinking about how we are going to sustain urban irrigation. It is important to base urban irrigation as part of livable city agenda integrating perspectives from natural and social sciences, economics, government, industry and community (Basant, 2016)

Therefore it is very essential to understand the influence of sunlight on Mid-rise building as well as its influence on solar radiation and daylighting factor for the internal spaces. (Terrapin , 2014) Solar access is a crucial criterion in energy efficient design because higher solar radiation reduces heating loads of buildings due to passive solar heating capability and higher level of daylight penetration offers more comfortable indoor environments (Strømman-Andersen, J. and Sattrup, P.A. 2011).

The overall results of the solar access should be investigated in respect to the climatic conditions and the design should target to optimize the total building loads by making benefit from solar radiation. In this case, the urban geometry and density have significant impacts on both energy consumption and daylight availability related to neighboring buildings within a settlement that creates shaded areas by blocking the solar access. (Van Escha, et al 2012).

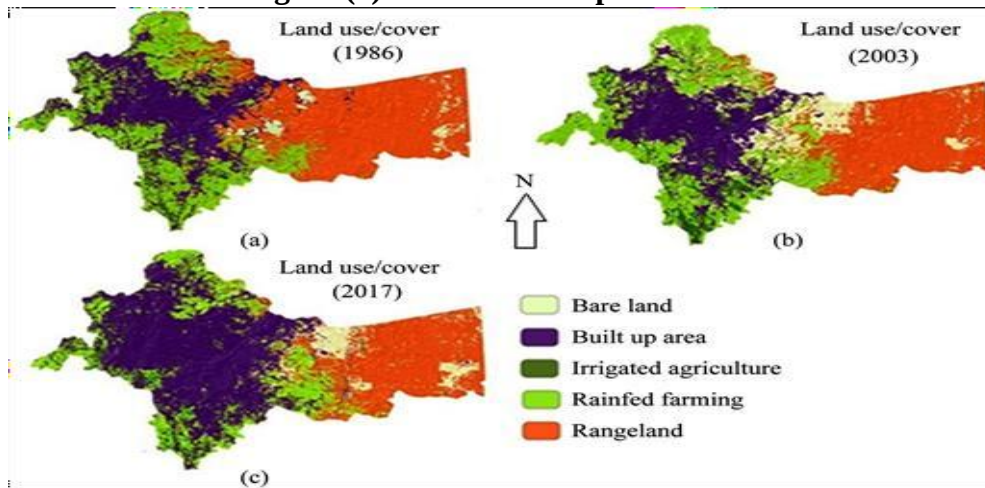
Therefore, the impact of the ratio of building height to street width (H/W ratio) should be investigated within a part of urban design process by calculating shadow densities of neighboring buildings. In other words, the settlement pattern that maintain its existence for many years and significantly affect the performance of the buildings, should be designed based on urban geometry to ensure adequate solar radiation and daylight in accordance with environmental conditions (Rattia, et al 2005).

The surface area to volume (S/V) ratio (the three dimensional extrapolation of the perimeter to area ratio) is an important factor determining heat loss and gain. The greater the surface area the more the heat gain/ loss through it. So small S/V ratios imply minimum heat gain and minimum heat loss. In hot dry climates S/V ratio should be as low as possible as this would minimize heat gain. In cold-dry climates also S/V ratios should be as low as possible to minimize heat losses. In warm-humid climates the prime concern is creating airy spaces. This might not necessarily minimize the S/V ratio. (Generalitat de Catalunya, 2004).

Mean radiant temperature (T_{mrt}) is one of the most important meteorological parameters governing human energy balance and thermal comfort outdoors, especially during clear and calm summer days (Mayer and Höppe 1987). Other factors that affect T_{mrt} are the thermal and radiative properties of surrounding surface materials ASHRAE (2001)

The phenomenon of the rapid urbanization in cities like Amman has also become one of the important topics in urban planning and sustainable development Figure (1). The rapid urbanization often leads to negative environmental impacts, including modifications on the urban microclimate. Those particularly at risk include the elderly, low-income earners and residents in urban areas of high population densities with limited surrounding vegetation. In Amman , there are residential suburbs for low-income people, which are built through the Housing & Urban Development Corporation HUDC.

Figure (1) : urban development of Amman



(Source :GMA 2007)

These residential neighborhoods suffer from a climate-related environment characterized by humidity, high temperatures and poor construction materials. In this study we highlight the environmental problems in outer spaces and their relation to comfort through study the buildings height, by studying the public housing project (the Abu Alunda housing project) in southeast of Amman and private housing project in Al-Muqablain in southwest of Amman. Figure (2).

Figure (2) : the Abu Alunda housing project



(source: :<https://www.ammonnews.net/article/137739>)

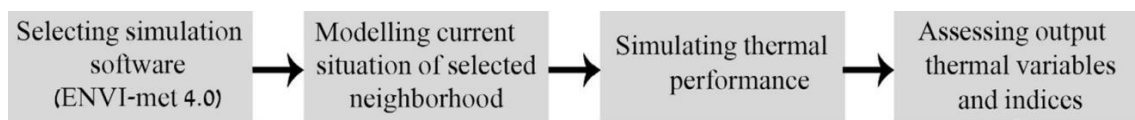
The idea of ENVI-met is to built up houses and to find out the changes of the environmental and climatology conditions in urban areas. ENVI-met give the solution how the urban environment could be designed to give the best possible microclimate conditions to the citizens, which is very important for human health. It is possible to find out the effects of wind gusts caused by jet effects at building corners. With the program ENVI-met, environmental planers and architects will have a good quality of urban areas and they can aware the urban microclimate. (Sodoudi Sahar, 2012)

1. Research methodology

A quantitative approach to the climatic parameters has confirmed by use simulation tool, ENVI-met Version 4.3 BETA V, is used to investigate the microclimatic changes with building height factors. Use simulation ENVI-met to simulate Air temperature, Radiant temperature And Relative humidity For three hypothesis of building height. The simulation began at 15:00 P.m. on 21 /6 /2019 and the simulations for 1 h.

The simulation study includes the following :

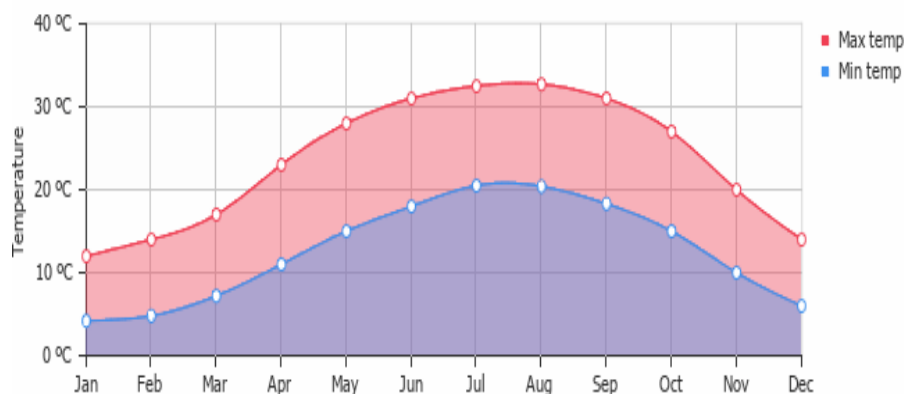
- Public Abu Alunda Residential housing project (Kareem housing) in the southeast of Amman
- private Residential housing building neighborhood located in Al-Muqablain in southwest of Amman



2. Public housing project (Kareem housing- Abu Alunda) study

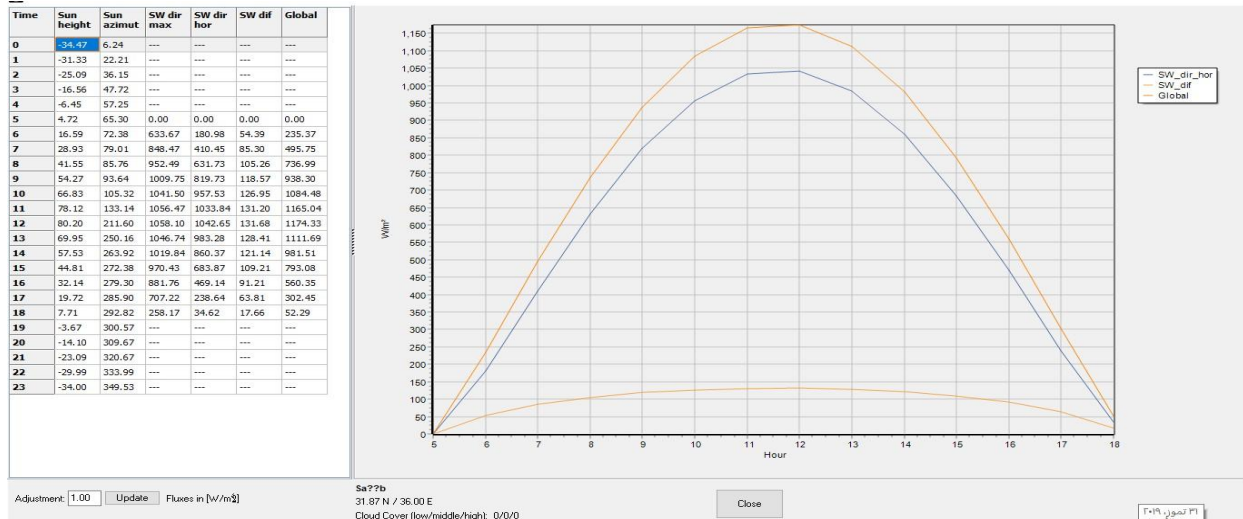
Amman (Abo- Alanda) has sunny summers (June to setemper) and fairly cold winters (December to February). Summer temperatures can reach in excess of 35°C during the day, but evenings are generally cool. In winter, minimum temperatures can reach 0°C. Spring and autumn have the most comfortable climate with average temperatures in the range of 16 to 20°C. Figure (3). (Cimate Amman).

Figure (3) climate of residential complex of a Kareem housing project



source: <https://ar.climate-data.org/location/6326/>

Sun radiation for 21/6/2019. Figure (4).

Figure (4) Sun radiation for 21/6/2019 of residential complex of a Kareem housing project

source: researchers

2.1. Abu Alunda housing project (kareem housing) location

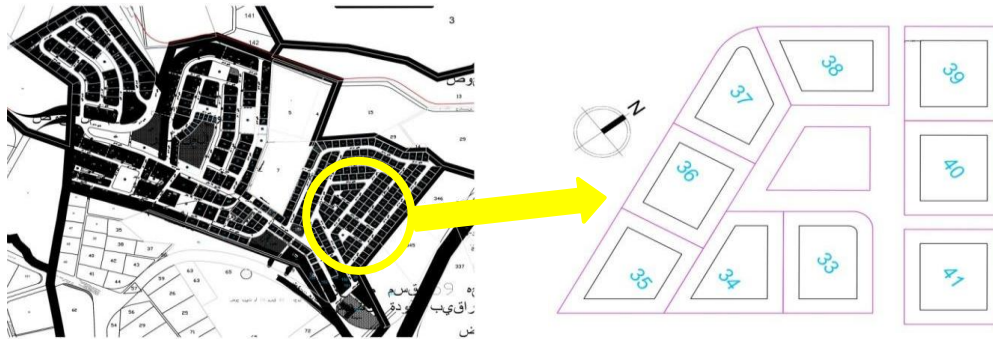
Abu Alunda is one of the highest in the south and east of Amman. It rises between 950_1010 meters from the sea. Abu Alunda limits the west of Qweismeh, south-west of Juweidah, south- east of Sahab. Figure (5).

Figure (5): location of residential complex of a Kareem housing project

source: Google Earth edeted byresearchers

Kareem housing project in Abu Alunda contains ten models of apartments ranging between 90- 120 square meters, ranging from 19 to 40 thousand dinars according to the area and 30 month soft monthly payments in monthly installments between 116-118 dinars, without a first payment. (UN Habitat, 2016) , And in this study we will take a piece of land intended to be a residential complex of a Kareem housing project. Figure (6).

Figure (6) residential complex of a Kareem housing project



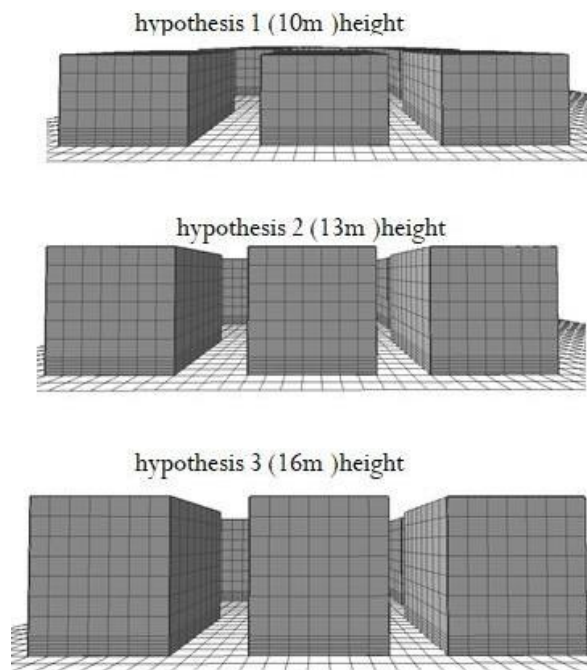
source: researchers

2.1.1. Hypotheses.

From the urban space utilization perspective, considerable economical and environmental values can be created in an effective space by increasing building height.

To investigate the effect of building height on urban thermal environment in the residential area, three Hypotheses of building height are simulated (10-13-16) m. The simulation began at 15:00 P.m. on 21 /6 /2019 and the simulations for 1 h. Figure (7).

Figure (7) Hypotheses of Kareem housing project building heights



source: researchers

- **Hypotheses 1:** building heights 10 M. (Figure 8)

Figure (8) Suggested building heights 10 M.

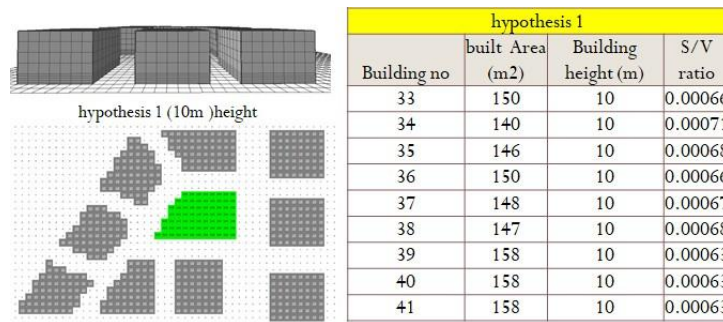


Figure (9) :Air temperature map of the Hypothesis 1 where the height of buildings 10 meters

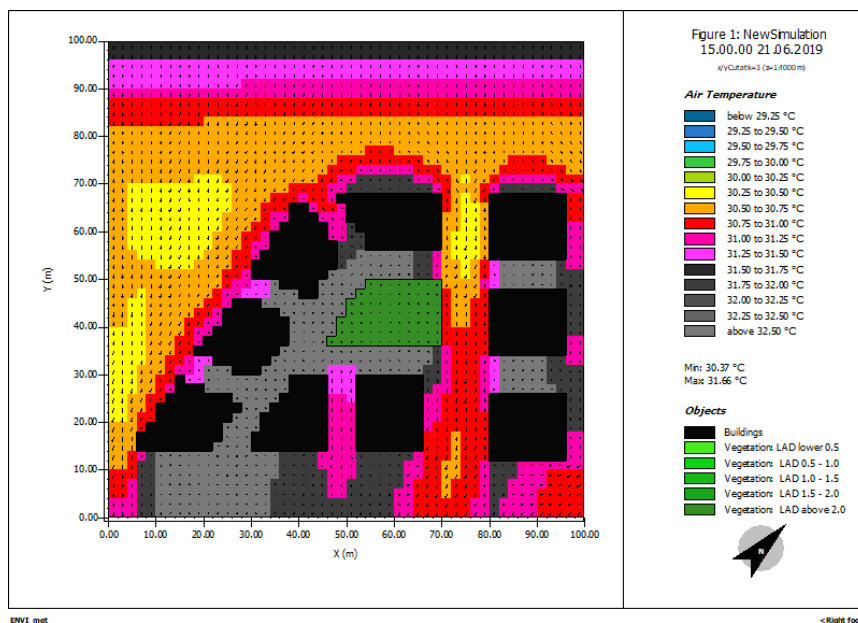


Figure (10) : Mean radiant temperature map of the Hypothesis 1 where the height of buildings 10 meters

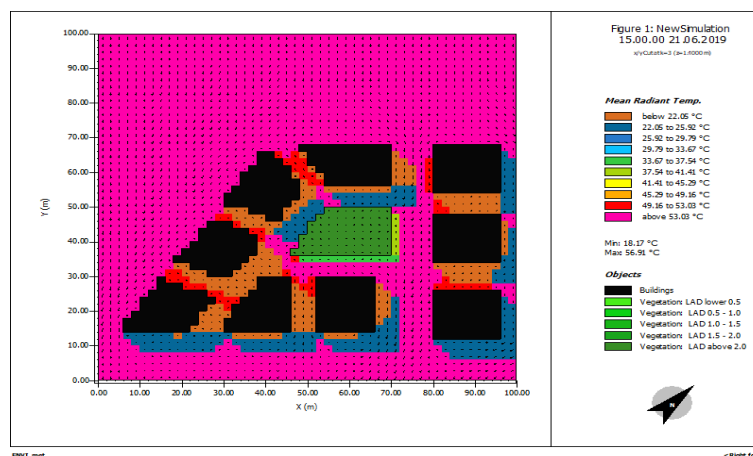
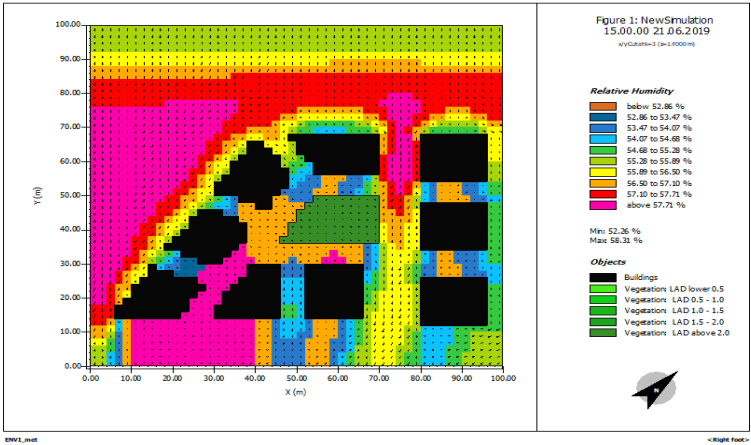


Figure (11) :Relative humidity map of the Hypothesis 1 where the height of buildings 10 meters



- Hypothesis 2: Buildings Height 13 meters.
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Figure (12) Suggested building heights 13 M.

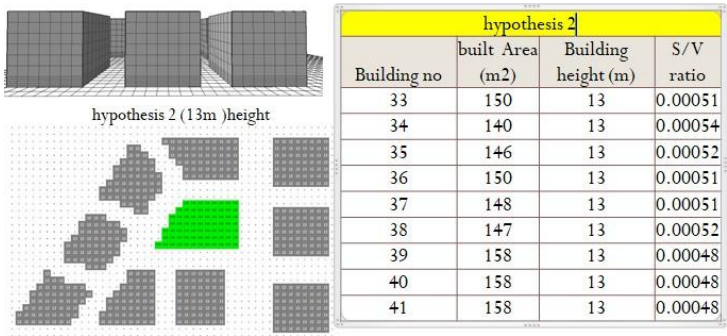


Figure (13) :Air temperature map of the Hypothesis 2 where the height of buildings 13 meters

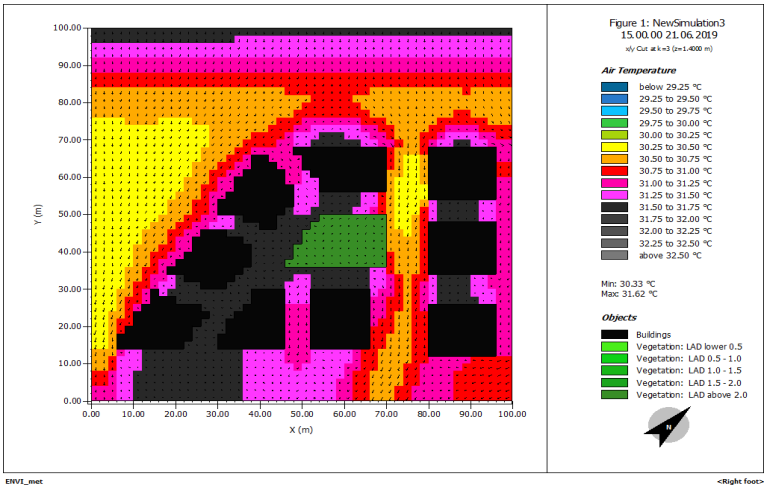


Figure (14) : Mean radiant temperature map of the Hypothesis 2 where the height of buildings 13 meters

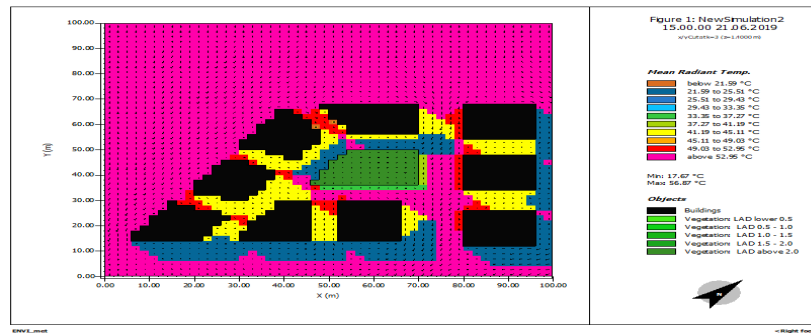
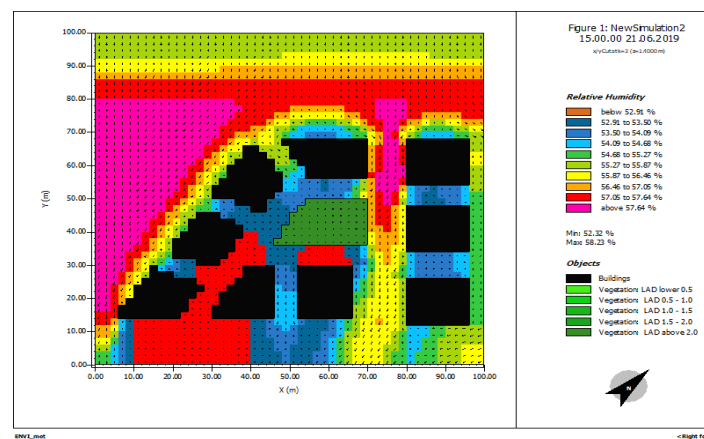


Figure (15) :Relative humidity map of the Hypothesis 2 where the height of buildings 13 meters



- **Hypothesis 3:** Buildings Height 16 meters.

Figure (16) Suggested building heights 16 M.

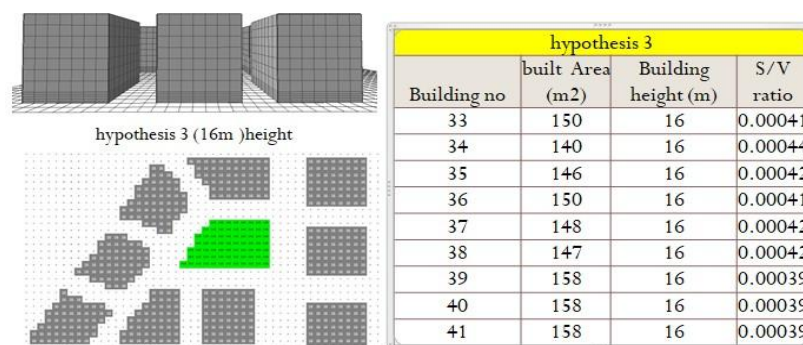


Figure (17) :Air temperature map of the Hypothesis 3 where the height of buildings 16 meters

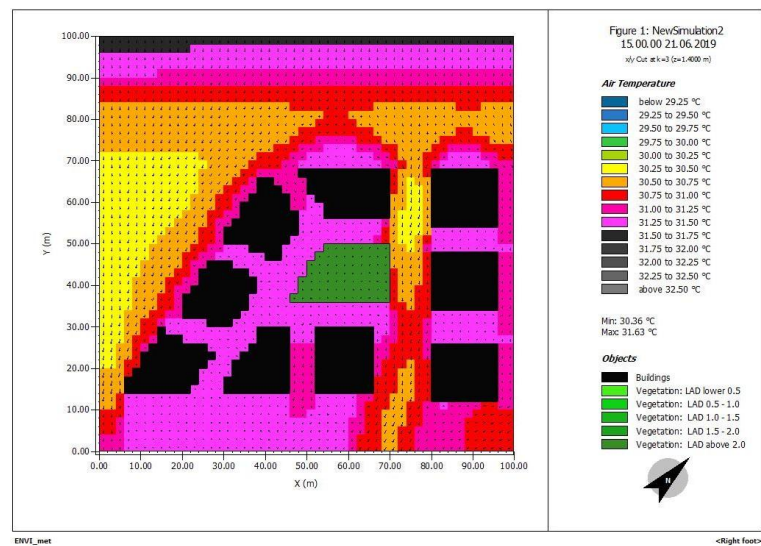
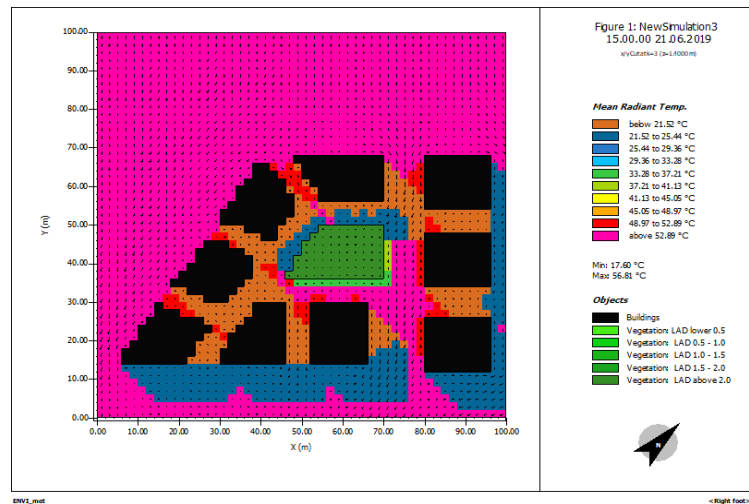
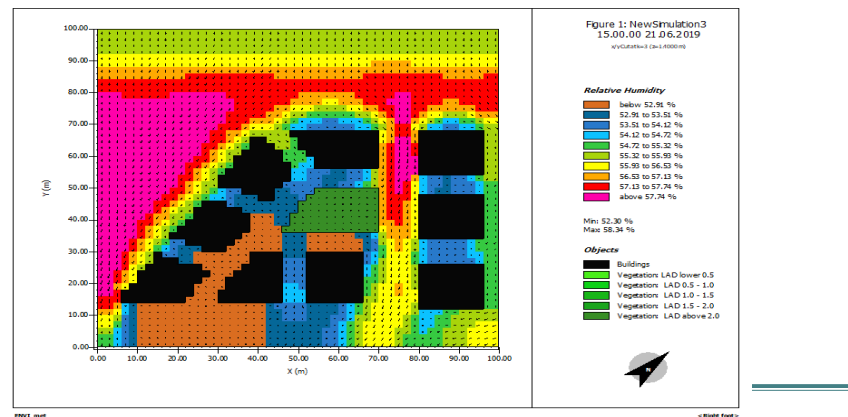


Figure (18) : Mean radiant temperature map of the Hypothesis 3 where the height of



buildings 16 meters

Figure (19) :Relative humidity map of Hypothesis 3 where the height of buildings 16 meter



2.1.2. Abu Alunda housing project (kareem housing) simulation results

- The study concluded, however, that with the increase in height of buildings from (10 to 13 meters) to a decrease in the air temperature in the surrounding of buildings by (0.5-1 c), And when the height of buildings increases from (10-16 meters), the air temperature in surrounding of buildings decreases by (1-1.5 c).
- Increasing the proportion of shaded surfaces due to increased building height helps to reduce the thermal loads within residential units, thus reducing energy consumption.
- The humidity decreases from (57%) to (52%) when increasing the height of the buildings from (10m) to (16m). This helps to achieve the comfort of the users of spaces between the buildings by reducing body temperature down wet and increase sweating.

Conclusion

This study simulated the relationships height and city microclimate by ENVI-met to investigate the effects of height factor on the thermal environment of residential areas .

Returning to the hypothesis posed at this study, building height plays a great role on the thermal comfort of a city. It directly affects people's behavior and usage of outdoor spaces. Therefore, an environmentally conscious urban regulation solution should give high priority to the thermal comfort implications of urban microclimate.

Urban planning regulations are mostly guiding the city development in a certain period. These regulations include the instructions that lead the city development in terms of building constructions, urban spaces, parks, streets, etc. In addition, the urban form is strongly influenced by urban planning regulations, such as zoning ordinances, which govern spaces between buildings, building heights, building footprints, etc. Consequently, urban planning regulations have a great impact on the microclimate in urban areas.

In order to reduce the negative climatic impacts in our cities, those involved in urban development, planning, and design should strongly act to incorporate climate knowledge into planning strategies and to create links between microclimate, thermal comfort, design, and urban planning regulations.

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