Quantitative Study of Green Area for Climate Sensitive Terraced Housing Area Design in Malaysia

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Neighbourhood plays a significant role in people’s daily lives. Nowadays, terraced housing is common in Malaysia, and green areas in the neighborhood are not used to their maximum. The aim of the research is to quantify the types of green area that are most efficient for cooling the environment for thermal comfort and mitigation of Urban Heat Island. Spatial and environmental inputs are manipulated for the simulation using Geographic Information System (GIS) integrated with computational microclimate simulation. The outcome of this research is a climate sensitive housing environment model framework on the green area to solve the problem of Urban Heat Island.

1.0 Introduction
In this modernization era, urban area attracts the largest share of development investment, energy and creativity. Today, 40 percent of the population of developing countries already lives in cities. By 2020, more than half of the population will lives in the cities, the rapid and largely uncontrolled population growth create a pattern of rapid urbanization (Global Report On Human Settlements, 2006). According to International Energy Agency, Geneva, (2009) by 2030 average air temperature will rise of 2°C represent a critical limit.

Urban Heat Island is a phenomenon where the urban temperature is higher than its rural surroundings (Oke, 1998). According to Rizwan Ahmed Memon et al., (2008) study, there are three causes of Urban Heat Island which are:-

i). Anthropogenic heat released from vehicles, power plants, air conditioners and other heat sources, and due to the heat stored and re-radiated by massive and complex urban structures.

ii). Huge quantities of solar radiation due to less vegetation due to its typical land use.

iii). High roughness structure is another problem of urban areas, which reduces the convective heat removal.

According to Unger, (2004) study, UHI effect on hot climate region is more than cold climate region on human comfort and mortality and energy use, air pollution, hence mitigation methods to solve UHI is very important.

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The lack of specific information about the benefit of vegetation as a mitigation method currently preventing the green infrastructure approach from progressing (Mathey et al., 2011). For example, cooling effects are particularly high in large parks or areas of woodland, but combining the patches of green space into an interconnected green infrastructure, the impact of cooling will be much better, yet it also serves as functional as recreational, ecologically and socially. As said by Rizwan et al., (2007) there is a need to develop a strategy to solve Urban Heat Island by design and planning framework.

There is not much technical information on different green-spaces and even less about what types of green spaces is better to mitigate urban heat. Chang, Li, & Chang (2007) also questioning the cooling intensity of green spaces towards surroundings (Chang et al., 2007). However, it will be interesting to provide a quantitative analysis on green spaces so to determine and select the most promising method for implementation in urban design and planning decisions. As McPherson (1994) said the designer are questioning where and how to handle vegetation in park, streets and residential area to improve climate change. Nevertheless, in hot humid zone, including Malaysia, there are still lack of research on the relationship between landscape elements such as building layout, road layout or planting situation and surrounding physical environment such as temperature, humidity or wind speed from the scientific perspective (Kei, Said, & Rasidi, 2010). Kei, Said, & Rasidi (2010) also said that there is a necessity to explore natural and physical outdoor environment terraced housing in Malaysia.

2.0 Methodology/Conceptual Framework
The aim of this paper is to understand the quantifying concept on the most suitable green spaces in local scale; a neighborhood area in hot-humid climate using numerical simulation. In this part, the detail of methodology model will be discussed.

Firstly, to find an appropriate site with a planning theme, then check the real measurement at the site. After that, doing an experiment in a different configuration and scale of landscape and build environment and understand about the model as a planning and design tool (Ozkeresteci, I., Crewe, K., Brazel, A.J. and Bruse, 2003). The chart below shows the process and preparation of data.

![Figure 1. Process of integrated environment for data management and microclimate simulation](image-url)

Geographical Information System (GIS), a geospatial tool has the ability to analyse the interaction between the environment and buildings effectively (N. Hien, Kardinal, & Liang, 2011). Thus, it is necessary to use this technology to evaluate environmental context, and adapt it and in current real-
life planning issues (Ozkeresteci, I., Crewe, K., Brazel, A.J. and Bruse, 2003). In this study, GIS play a crucial role as data storage with spatial information.

ENVI-met is software developed by Michael Bruse, of the University of Bochum, Germany. This software will be used as evaluation software for the digital model. The numerical simulations are a three-dimensional non-hydrostatic climate model that able to model surface atmosphere vegetation system. Some research paper on ENVI-met is compared as the table 1, to get some ideas how ENVI-met is used as a simulation tool.

**Table 1. References studies for comparison**

| Reference, Location and description of Site | Objective and Findings |
|------------------------------------------|------------------------|
| Bruse & Fleer (1998) Simulation on a designated small park in CBD area. The overall size of simulation is 1200 metre square. | **Objective** Bruse & Fleer (1998) focus on the microscale numerical simulation of surface–plant–air interactions inside urban structures. The investigation is on the feedback between artificial surfaces like buildings and vegetation inside street canyons, backyards or greens. **Findings** The interactions between surfaces, plant and the atmosphere inside the urban environment are complex and can offer a distinct pattern. |
| Shinzato, Paula (2012) 9 blocks of base case with 9.6 metre square each simulated with 4 different scenario based on Sao Paulo climatic condition. | **Objective** The research focus is to find out intensity effect of vegetation in urban microclimate conditions with different forms of green space by simulating four different scenarios with different the green area distribution: Scenario 1: a central park occupying one entire block; Scenario 2: a park in a linear form with a stream in the middle; Scenario 3: a small pocket parks in every block and Scenario 4: trees only in the sidewalks. **Findings** There are differences among air temperatures inside the green areas and the surrounding streets. Thus the spatial distribution of the green space shows a minimal effect and does not go far from the green model. So, it is better to distribute green space in small groups of trees than a large park. |
| W. N. Hien & Jusuf (2008) National University of Singapore Campus with area of 1.5 kilo metre square. | **Objectives** To do an evaluation on NUS Master Plan 2005 by providing the quantified data on its urban elements (building, pavement and greenery). The comparison is on NUS current condition greenery: 1. NUS Master Plan 2005 2. Simulated rooftop greenery. **Findings** The research found out the presence of greenery is one of the methods to make the NUS Master Plan 2005 better than just building buildings and ignoring the greenery, so adding a significant amount of greenery play a significant role in reducing heat. |

From the table, the inference is the sites chosen are depend on the objective of the research; thus it is vital to have a clear objective before starting any simulation. The simulation manipulates real site’s data and simulates it with different planning and scale to achieve different finding or impact of design and planning. It is proved from above research using ENVI-met as a microclimate simulation tool is a way to evaluate the importance of green space in hot and humid country, in this case this study is to discover effects of different types of greenery in neighborhood area.
3.0 Site Selection and Digital Simulation

The selection of the site is depending on representation of meteorological environment of a place for general climatological purposes (Oke, 2006). In this case, a housing area with different types of green space is chosen for the simulation purpose.

There are 3 types of horizontal scale of interest by Oke, (1984) which are microscale, local scale and mesoscale. This site is a local scale site that consists of landscape features that exclude microscale effects. According to Oke, (2006) classification of distinct urban form in appropriate decreasing order of their ability to impact local climate, the urban climatic zone in this area is categorized into highly developed, low or medium density urban with large low building and paved parking and medium development that have low density suburban with 1 or 2 storey houses. In this case, this area has roughness class of 5 or 6, aspect ratio of 0.05-1 and build impermeable of 35-95%.

3.1 Location and Model Development

The chosen area is at Taman Bukit Indah, Johor Malaysia. The study area is located at the southern part of Peninsular Malaysia with coordinate of 1°28’52”N 103°39’21”E. This housing area is launched in 1997. Within this area, there are varies of green spaces such as neighborhood park, local park, play lot, linear park, roads medians and courtyard. The average building height is 8 metre. The figure below is the site selected.

![Figure 2. Key Plan](image1)
![Figure 3. Location Plan](image2)
![Figure 4. Site Plan](image3)

3.2. Developing Dataset

Data identification is based on the aims of the research. So long-term site-specific meteorological records are crucial because the information is useful for making ‘reasonable’ planning decision (Ng, 2011). The dataset are basis for the simulation; thus it is necessary to collect a reliable dataset.

| Category          | Type                  | Source                                                                 |
|-------------------|-----------------------|-----------------------------------------------------------------------|
| 2D Vector (polygon) | Cadastral Data        | JUPEM (Department of Survey and Mapping Malaysia)                     |
|                   | Landuse               | JUPEM (Department of Survey and Mapping Malaysia)                     |
|                   | Green space           | Site                                                                  |
|                   | Road                  | JUPEM (Department of Survey and Mapping Malaysia)                     |
|                   | Tree                  | Site                                                                  |
| 2D Vector (Line)  | Aerial photo          | Google Earth                                                          |
| 2D Vector (point) | Mean temperature      | Malaysia Meteorological Department                                    |
| Image data        | Mean relative humidity| Malaysia Meteorological Department                                    |
| Climatic Data     | Mean Surface wind speed | Malaysia Meteorological Department                                   |

3.2.1 Spatial Data And Relative Data Collection
The initial data in table 2 shows the collected is for digitizing purpose in AutoCAD then integrated with spatial information in ArcGIS. It will then convert into ASCII format that compatible with ENVI-met.

3.3 Numerical Simulation
The ENVI-met simulation is built with according to the actual site geometry. The maximum building height is 8 metre tall. There are three focus areas with dimension of 240 metre x 240 metre all with 1 metre x 1 metre horizontal x 2 metre vertical resolution. The layout of the area is illustrated in the figure below.

These areas are simulated in two scenario one with trees and another with grass only. It will simulated for 12 hour from 6 a.m. until 6 p.m. The initial parameter input is typical average collection of meteorological data. ENVI-met simulation needs some main initial parameter for the numerical simulation. The initial data that need for this simulation is in table 3:

| Parameter                                      | Value       |
|------------------------------------------------|-------------|
| Wind Speed in 10 m ab. Ground [m/s]            | 1.6         |
| Wind Direction (0:N..90:E..180:s..270:W..)     | 40          |
| Roughness Length z0 at Reference Point         | 0.1         |
| Initial Temperature Atmosphere [K]             | 298.5       |
| Specific Humidity in 2500 m [g Water/kg air]   | 7           |
| Relative Humidity in 2m [%]                    | 87.9        |

3.4 Initial Data Comparison
From the model prepared, table 3 shows the build area at area1 and 2 both have 54.1% and 69% impermeable area. This area is categorized as Urban Climatic zone number 5 which is medium development, low density suburban with 2 storey house. Meanwhile, area 2 is categorized as highly developed with medium density urban large low building and paved parking.

| Area     | Build Coverage | Area 1 (metre square) | Area 2 (metre square) | Area 3 (metre square) |
|----------|----------------|------------------------|------------------------|------------------------|
|          | (Percentage %) | (Percentage %)         | (Percentage %)         | (Percentage %)         |
| Build    | 31176          | 54.1%                  | 41292                  | 69.0%                  |
| Coverage |                |                        |                        |                        |
| Area     | 41292          | 71.7%                  | 41292                  | 69.0%                  |
| Green    | 39768          |                        |                        |                        |
| Space    | 26424          | 28.3%                  | 16308                  | 31.0%                  |
| Area     |                |                        |                        |                        |
The result of the simulation will be debate on specific air temperature of determine points to verify the cooling intensity of green spaces. Hence, the suitable green spaces allocation will be found out with numerical proof.

4.0 Conclusion & Future Prospect
ENVI-met reproduces the observed data with a sufficient accuracy (Lahme & Bruse, 2002). It has been proved that ENVI-met is a reliable tool to simulate the different urban scenarios (Zhao, Yang, & Meng, 2009). In the future, the interrelation of build coverage area and green spaces will be discussed. The most suitable green spaces will be identified as green space is one of the controllable factors in design and planning as said by Memon, Leung, & Chunho (2008). As a summary ENVI-met can be a new tool for urban planner, architect, landscape architects to test their design implications to solve the Urban Heat Island and reduce global warming. Thus, to understand the methodology and concept of ENVI-met is crucial.

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