Microclimate landscape design at southern integrated terminal
Bandar Tasik Selatan, Kuala Lumpur

L H Phin¹, I Krisantia²*
¹Landscape Architecture Department, Faculty of Design and Architecture, Universiti Putra Malaysia, Malaysia
²Landscape Architecture Department, Faculty of Landscape Architecture and Environmental Technology, Universitas Trisakti, Jakarta, Indonesia.

*Corresponding Author: inakrisantia@trisakti.ac.id

Abstract. Bandar Tasik Selatan is the integrated transport terminal has high energy consuming, high carbon emission and poor linkage. However, microclimate can be reduced through landscape design. This paper is a study to achieve energy efficiency and improve microclimate in the urban area. The research area is at Southern integrated terminal Bandar Tasik Selatan Kuala Lumpur Malaysia. It is carried out through a case study and microclimate analyzed using System Modeling method. System modelling using in this research is system energy budget of the microclimate at a site is a balance between the radiant energy supplied and the energy removed by all consumers. The finding indicated the microclimatic components that can be modified through landscape design are solar radiation, wind and precipitation can create thermal comfort, energy efficiency and others benefits. Through this research, provide more green space to achieve energy efficiency and improve microclimate of the site, introducing vertical landscape and proper planting selection to improve air quality, introducing green energy as part of the source of power supply and to promote integration of terminal building and rail systems by unify them using softscape.

Keywords: energy budget, microclimatic, urban landscape

1. Introduction
Microclimatic landscape design requires knowledge of prevailing climate conditions, understanding of the ways in which objects in the landscape affect climate to create microclimates. The microclimatic components that can be modified through landscape design are wind, radiation and precipitation. Besides, air temperature and humidity can be altered and can have an effect on human comfort or to reduce energy consumption of buildings [1].

Studies by the Lawrence Berkeley National Laboratory estimate a 25%–50% reduction in annual cooling energy consumption through well-designed landscape design. Refer to researcher [2] since climatic factors affect energy use, therefore, energy usage in cooling of building can be control by controlling the microclimate. Natural element such as landform, vegetation, wind flow, water bodies and more can be make use to modify the surrounding microclimate of buildings. Thus, the energy consumption of the building will be reduced.

Other elements in landscape planning for energy conservation include building orientation, selection of materials and more. It is clear that microclimatic landscape design can help create energy efficiency and it will be possible to improve the urban fabric whilst minimizing our environmental impact include minimizing energy cost and reducing air pollution [3].
Therefore, it is vital to implement the design to all new planning. The other benefits of microclimatic design include ensuring outdoor human thermal comfort, to ensure environmental quality, to reduce pollution, and more.

Microclimate is the condition of the solar and terrestrial radiation, wind, air temperature, humidity and precipitation in a small outdoor space [1]. Microclimatic design requires a conceptual understanding on how microclimatic components such as wind and solar radiation, can be significantly affected from landscape elements [1]. Plants have a strong effect on microclimate. Trees and green spaces can help to cool our cities and save energy. Trees can provide solar protection to individual houses during summer and evapotranspiration from trees can reduce urban temperatures. Trees also help mitigate the greenhouse effect, filter pollutants, mask noise, prevent soil erosion, and calm their human observers. Shading from trees is an effective way to significantly reduce energy for cooling purposes.

System energy budget of the microclimate at a site is a balance between the radiant energy supplied and the energy removed by all consumers. Supplied Energy removed by consumer are account of terrestrial radiation, conduction, evaporation, and connection consumers. The four major available consumers are terrestrial radiation by objects at the site, conduction of heat into objects, evaporation of water, and convection of heat from objects into the air by wind.

Southern Integrated Terminal Bandar Tasik Selatan is high energy consuming since it is equipped with a 6-storey terminal building and three rail systems which are KTM, LRT and KLIA Transit. The transit zone is definitely the gathering point of buses, cars and peoples, thus, it is high carbon emissions. Besides, there is poor linkage between terminal building and rail stations. However, microclimate can be reduced through landscape design. This paper is on the study to achieve energy efficiency and improve microclimate in the urban area.

2. Research Method

2.1. Location
Southern Integrated Terminal Bandar Tasik Selatan Kuala Lumpur

2.2. Data collection
Data collected in the form of primary data and secondary data, in the form of physical data and non physical site

2.3. Method
A case study and microclimate analyzed using System Modeling method. System modelling using in this research is system energy budget of the microclimate at a site is a balance between the radiant energy supplied and the energy removed by all consumers [1]. Radiant energy supplied is a radiant energy Supplied. Energy removed by consumers is account of terrestrial radiation, conduction, evaporation, and connection.

The four major available consumers are terrestrial radiation by objects at the site, conduction of heat into objects, evaporation of water, and convection of heat from objects into the air by wind [1].

![Figure 1. Illustration of Energy Budget](image)
3. Results and Discussion

3.1. Climate
Kuala Lumpur has a tropical rainforest climate which is warm and sunny, along with abundant rain fall. The average temperature in Kuala Lumpur is 27.5°C. Kuala Lumpur’s climate receives an average of 2,409 mm of rainfall per year or 201 mm per month. The average annual relative humidity is 62.6% and average monthly relative humidity ranges from 58% in March to 66% in May & November. There is an average of 2,228 hours of sunlight per year with an average of 6.1 hours of sunlight per day.

Solar energy and surface at Kuala Lumpur insolation is a measure of solar radiation energy received on a given surface area in a given time. The average insolation at Kuala Lumpur is 4.8 kWh/m2per day (Table 1).

| Variable               | I    | II   | III  | IV   | V    | VI   | VII  | VIII  | IX   | X    | XI   | XII  |
|------------------------|------|------|------|------|------|------|------|-------|------|------|------|------|
| Insolation, kWh/m²/day | 4.29 | 5.06 | 5.22 | 5.33 | 5.08 | 4.91 | 4.87 | 4.99  | 5.04 | 4.83 | 4.21 | 3.77 |
| Clearness, %           | 0.45 | 0.50 | 0.50 | 0.52 | 0.51 | 0.51 | 0.50 | 0.50  | 0.49 | 0.48 | 0.43 | 0.40 |
| Temperature, °C        | 24.35| 24.98| 25.02| 26.07| 26.10| 25.73| 25.34| 25.39 | 25.50| 25.73| 25.26| 24.58|
| Wind speed, m/s        | 3.56 | 2.97 | 2.61 | 1.61 | 1.58 | 2.58 | 2.58 | 2.78  | 2.17 | 1.72 | 2.58 | 3.56 |
| Precipitation, mm      | 147  | 137  | 218  | 264  | 210  | 130  | 141  | 154   | 190  | 268  | 278  | 232  |
| Wet days, d            | 14.8 | 14.6 | 17.2 | 19.6 | 16.2 | 12.3 | 14.2 | 15.4  | 18.2 | 22.1 | 24.8 | 21.1 |

The shadow of terminal building is most obvious because the height and size of terminal building. During morning, the terminal building is only able to provide shade to west side of the building while the other areas are exposed to the sun. On the other hand, afternoon sun can shade the east side of the building. Prevailing wind at the site is from North West direction. Therefore, the potential area to develop for windy cooling purpose is area facing North West direction. Figure 2 shows the sun direction and the compare is on of shadow terminal building at 8am, 2 pm and 5pm.

**Figure 2.** Analysis of microclimate.

3.2. Vegetation
The plants around Southern Integrated Terminal at Bandar Tasik Selatan are mainly the introduced landscape trees. Most of them are not mature trees since they are just newly planted at the site. The plants selections are lacking in provide shade and trap air particulates.

3.3. Topograf, Hidrology
The general topography of the site is almost flat, where it has elevation are within 40 to 50 meter above sea level. Therefore, the site is very suitable for development. The lowest elevation on site is at retention pond, which is below 45 meter above sea level. The elevation is become higher with the distance from retention pond. The retention pond is called ‘Kolam Pemadam’. It is an ex-mining pond Kampung Malaysia Raya. The function of the pond is to cater the large flow of storm water to avoid from flooding.
of this area. There is water inlet and outlet that allow water flow in and out. The retention pond has been modified through reclamation while constructing the Southern Integrated Terminal Bandar Tasik Selatan.

3.4. Visual
As a summary of visual study, the categories of views at the site are mostly ordinary views with visual amenities of retention pond and main terminal building. Some views that have portraits the sense of place as transportation hub are under category of exceptional view.

3.5. Building
The location of terminal building, LRT, KTM and KLIA Transit station and the pedestrian bridge. Terminal building have total of 6 levels with height of 46 m. The terminal building is fully air conditioning and there is excessive lighting to light up the building during night, herefore the energy consumption of the building is very high. The existing and new pedestrian bridge is 1 level different. There is no proper ramp for users. This will trouble the users if the lift is not functioning. The width of the pedestrian bridge is notable to cater large flow of users during peak hour.

3.6. Land use

| Land use                          | Area (m²) | Percentage (%) |
|-----------------------------------|-----------|----------------|
| Retention pond                    | 108,000   | 32.5           |
| Public open space                 | 46,030    | 13.8           |
| Terminal, station, parking and road system | 178,730   | 53.7           |
| Total                             | 332,760   | 100.0          |

Generally, the site has developed and there is limited space to be developed except for the public open space around retention pond. The land use for terminal, station, parking and road system is highest, which is 53.7%. It is apparently that road system and railway have monopoly large area of the site since it is a multi-modal integrated public transportation terminal. Therefore, large paved area has contributed to urban heat island effect and road system is highest no clear orientation can contributed to urban heat island effect because street orientation is a fundamental factor in providing shading [5]. The main green space at the site is the public open space around retention pond, which is 13.8%. It is definitely ot enough green space at the site to balance with the paved area (Table 2). Therefore, all available open space should be utilized to increase green space.

3.7. Implementation Microclimatic in Landscape Design

3.7.1. Programing
The programmes in the relation with Southern Integrated Transport Terminal include: Pick up area, Drop-off area, Parking, Waiting area and Meeting area.

While programmes in the relation with objectives include: Green area, Vertical landscape, Linkage, Green energy, Green roof according to programmes a conceptual plan of space has developed. Available open spaces are mostly proposed as green space to achieve the design objective. These supported that green space measures contribute to a decrease in local temperatures of up to 2°C for summer conditions [6]. Pick up area and drop-off area are separate but near to each other to avoid congestion. Solar panel is potentially to install on the rooftop of arrival platform terminal. Rooftop of car park building is utilized for green area. Elevated plaza and extended platform are function as waiting and meeting area.

3.7.2. Design Concept
A good microclimate can also be one that is energy efficient, or water efficient, or in some way makes a more positive environment [7]. Using concept of ‘Manipulate the microclimate’ to utilize and control the microclimatic elements i.e. solar, radiation, wind, temperature and precipitation at Southern Integrated Terminal Bandar Tasik Selatan which are renewable and sustainable natural resources in landscape design to benefit both peoples and environment. By using microclimatic landscape design, it will be possible to improve the whilst minimizing our environmental impact include minimizing energy cost and reducing air pollution.

The key consumers that influence the heat that feel by the human and objects of site is terrestrial radiation. Since Malaysia possesses a humid tropical climate with warm and uniform temperature, the result that we want to get is to reduce the terrestrial radiation. Therefore, if we would like to reduce terrestrial radiation, we should reduce radiant energy supplied, increase conduction, evaporation and convection see Figure 3. The factors how to reduce terrestrial radiation is listed on Table 3.

| Energy supplied          | Energy removed by consumer |
|--------------------------|----------------------------|
| Radiant energy supplied  | Conduction                 |
| Terrestrial radiation    | Evaporation                |
|                          | Convection                 |
| - Increase shading       | - Try to achieve lower surface temperature |
| - Higher albedo (higher solar reflectivity) | - Higher admittance |
|                          | - Exist of water            |
|                          | - More plants               |
|                          | - Do not block the wind     |

**Figure 3.** Conceptual Plan of energy budget.

Microclimatic landscape design is important to achieve energy efficiency, human thermal comfort and soon. Therefore, energy budget is taken into consideration such as low radiant energy supplied, high conduction, high evaporation and high convection need to achieve. Vertical landscape and shade tree with multiple canopy layers are proposed to intercept solar radiation to reduce radiant energy supplied especially shade tree with multiple canopy layers [8] and higher tree [9] and types of trees among other landscape elements strongly ameliorate the microclimate [10]. For the area that facing prevailing wind from North West direction tall trees are proposed to allow wind to blow through. This will increase convection. The retention pond and plants will contribute to increase evaporation. Material selection should be high admittance to increase conduction. To achieve the objectives, green space is an important factor. Since there is limited space for green space on ground, so vegetated wall, green roof and roof top garden are proposed to increase green space of the site. According to programmes, a conceptual plan of
space has developed. Available open spaces are mostly proposed as green space to achieve the design objective. Pick up area and drop-off area are separate but near to each other to avoid congestion. Solar panel is potentially to install on the rooftop of arrival platform terminal. Rooftop of car park building is utilized for green area. Elevated plaza and extended plat form are function as waiting and meeting area.

4. Conclusion
Southern Integrated Terminal Bandar Tasik Selatan is an essential infrastructure which is needed to lead our country towards a developed country. There will be more similar infrastructure to be build all over Malaysia to upgrade the transportation system of Malaysia and thus provide convenient public transport service to residents. Malaysia. But nowadays environmental issues are becoming more serious and global awareness towards the issue is high. Therefore, the built environment must be integrated with the existing green environment to reduce the negative impacts towards our Earth. Microclimate element such as solar radiation, wind and precipitation are the renewable and sustainable natural resources. We should utilize them to benefit both peoples and environment. Solar radiation can be collected as solar energy and convert to electricity to achieve energy efficiency, wind can be utilized to provide cooling effect to the surrounding and rainfall can be collected and reuse for other purpose. By using microclimatic landscape design, it will be possible to improve the urban fabric whilst minimizing our environmental impact include minimizing energy cost and reducing air pollution.

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