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GEOVISUALIZATION FOR MODERATING URBAN HEAT ISLAND TOWARDS GREEN CITY IN SHAH ALAM

Haslam Hussain , Abdul Rauf Abdul Rasam andZaharah Mohd Yusoff
Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA (Shah Alam), Malaysia
rauf@salam.uitm.edu.my, raufrasam@yahoo.com

Abstract
Previous studies have shown that the presence of urban heat island (UHI) can affect metropolitan regions. The UHI is a phenomenon where the absorption of solar radiation by mass building structures, roads, and other hard surfaces during daytime, is subsequently re-radiated to the surroundings and increases ambient temperatures at night (Wong & Yu, 2005). This paper shows how to simulate a green area in Shah Alam for cooling UHI-spots using three geoinnovative methods; geovisualization, location analysis,and green city index. Geovisualization is the visual critical analysis and geospatial presentation using integral approaches from scientific and information visualization, image analysis, exploratory data analysis, and GIScience. Satellite land surface temperature (LST) and digitized topographical maps show that Section 21 recorded higher temperatures or is a UHI-spot (33^oC-34^oC). Based on the location analysis, the spatial characteristics of the spot are industrial areas, populous areas, and near to main roads. Clearly, the areas with fewer plants always have higher temperatures,indicatingthat the role of green areas is essential in moderating the UHI severity in the city. The concept of selected green city indexes and Malaysian tropical forest are adapted to produce a proposed green city in Section 21 Shah Alam. The green elements need to be implemented in the study area such as sustainable shopping complex and housing, systematic office and hotel planning, and other green space.

1.   Introduction

Globally, the impact of urban heat island (UHI) is higher than previous time especially at populous and urban areas. The phenomena can heat the urban area by constructing building, road, industry and many more. If the development cannot be controlled wisely, urban heat island can occur in the area. There is great impact of urban heat island to human health such as heatstroke, heat exhaustion, heat syncope, and heat cramps. The population of Shah Alam has increased since University Teknologi MARA (UiTM) Malaysia and heavy industries developed in Shah Alam. Many immigrants come to Shah Alam to study and work especially in the industry sector. Therefore, the local authority of Shah Alam (MBSA) needs a systematic way in order to control the development to be greener or known as 'Bandaraya Anggerik'. Geovisualization is an important tool to explore spatial data sets. Although this approach a is rarely applied to specific fields of research, but it has an important potential to analyse huge sets of data. The goal of this study is to show the capacities of exploratory spatial data analysis and geovisualization applied to planning city and to environmental information characterizing places of green elements in Shah Alam.

2.   Moderating Urban Heat Island towards a Green City

Cooling urban heat island (UHI) by creating a proposed green city in Shah Alam is the central issue in this study. Green area plays a pivotal role in improving urban environment, such as preserving water and soil, controlling temperature and humidity of air, preventing pollution, flood prevention, functioning as buffer between incompatible land uses, preserving natural habitat and providing space for recreation. Efficient methods need to be explored as there are a lot of problems to build a green town in the city such as higher cost, crowded and protest from people and many more.

2.1   Causes and Effects of Urban Heat Island (UHI)

The UHI is a phenomenon where the absorption of solar radiation by mass building structures, roads, and other hard surfaces the during day, subsequently re-radiated to the surroundings and increases ambient temperatures at night (Wong & Yu, 2005). The progressive replacement of natural surfaces with built surfaces, through urbanization constitutes the main cause of UHI formation. Natural surfaces often composed of vegetation and moisture-trapping soils. Built surfaces composed of a high percentage of non-reflective and water-resistant construction materials. Consequencely, they tend to absorb a significant proportion of incident radiation, which is released as heat.

Spatial characteristics of UHI (e.g. development, growth, intensity, and spatial pattern) differ depending on where the measurements are made. The atmospheric UHI usually reaches its highest intensity on summer nights, and under calm air and a cloudless sky. This is because construction materials exhibit a high thermal, and consequently, they continue releasing heat slowly after sunset and even near dawn, when most of the rural surfaces have cooled down. Since urban temperature is strongly commanded by the high thermal inertia of the construction materials, the surface UHI usually reaches its highest intensity during the afternoon, when the urban surface has sufficiently warmed-up, thus maximizing its heat release (Figure 1). The UHI negative impact not only affect urban residents, but also humans and their associated ecosystems located far away from cities. In fact, UHIs have been indirectly related to climate change due to their contribution on the greenhouse effect, followed by global warming.
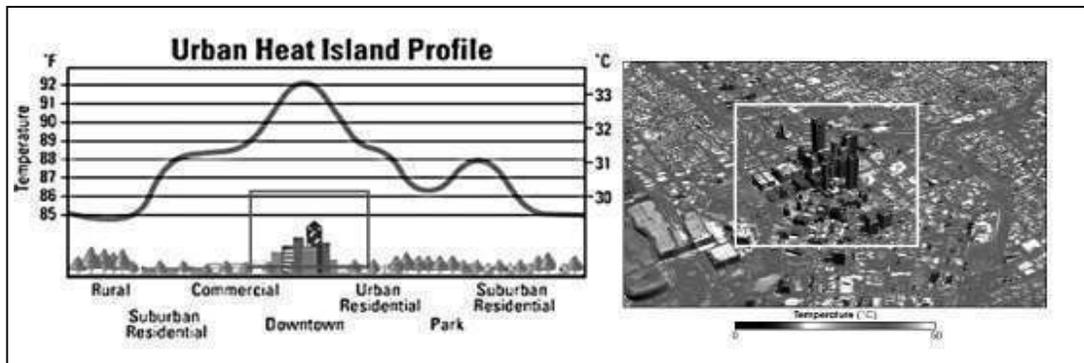

Figure 1: Typical Urban Heat Island Profile, with Higher Air and Surface Temperatures than Nearby Rural Areas
(Source: Pictures modified from Newhouse, 2008 and the NASA, 2011)

2.2 Green City

Green city approach is an efficient strategy in reducing UHI effects such as increasing the surface reflectively and enhancing vegetation cover. Since the definition of green city has subjective meanings to be translated into objective indicators or index of urban environmental quality, the author view is that a green city should get optimum marks when graded on global integrated green city index. Based on the Asian and European Green City Index, there are eleven indicators that affect all cities regardless of geography or time (Figure 2).

Figure 2: Integrated Green City Indicators

2.3 Geovisualization, GIS and Remote Sensing Images

MacEachren and Kraak (2001) stated geovisualization can be described as a loosely bounded domain that addresses the visual exploration, analysis, synthesis, and presentation of geospatial data by integrating

approaches from cartography with those from other information representation and analysis disciplines, including scientific visualization, image analysis, information visualization, exploratory data analysis, and GIScience. Geovisualization is becoming a diverse and multidisplinary field essential for increasing experiential representation, enhancing large and complex geospatial datasets, developing a new generation of geovisualization methods and tools, and creating a human entered approach to geovisualization. Recent researches from cartographic experts (MacEachren and Kraak, 2001; Dollner, 2001; Shafer,_, Guo,_) suggested the applications and features domain of geovisualization which include 3D models and space, web-based tools, geocollaboration tools, interactive visualization, multivariate and dynamically geospatial datasets.

3.   Methodology

The main methodology applied in this study is divided into three stages (Figure 3). The first stage is to determine UHI-surface temperatures using Landsat remote sensing technique and ERDAS software. The second stage focuses on creating geodatabase of the study area such as creating database and digitized base map using ArcGIS software. The third stage is to apply the selected green city indexes and concepts to develop a green city in Shah Alam.
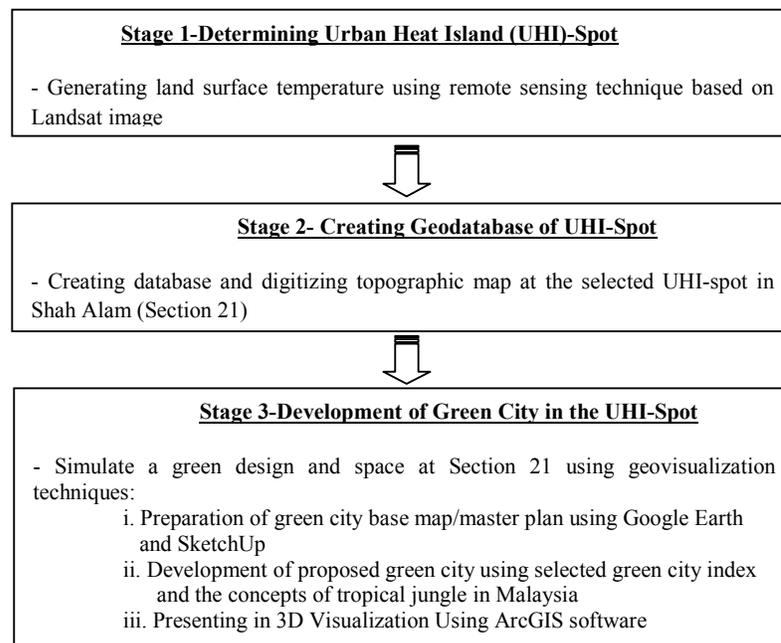

Stage 1-Determining Urban Heat Island (UHI)-Spot

- Generating land surface temperature using remote sensing technique based on Landsat image

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Stage 2- Creating Geodatabase of UHI-Spot

- Creating database and digitizing topographic map at the selected UHI-spot in Shah Alam (Section 21)

⬇

Stage 3-Development of Green City in the UHI-Spot

- Simulate a green design and space at Section 21 using geovisualization techniques:
      i. Preparation of green city base map/master plan using Google Earth and SketchUp
      ii. Development of proposed green city using selected green city index and the concepts of tropical jungle in Malaysia
      iii. Presenting in 3D Visualization Using ArcGIS software

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Figure 3: Flow Chart of Research Methodology

3.1   Stage 1-Determining Urban Heat Island (UHI)-Spot

Landsat image (2006), ERDAS Imagine 9.1 software and the method of Gain and Bias are integrated to produce temperatures zone and map of Shah Alam . Temperature can be calculated with model maker function In Erdas Imagine 9.1. The equations in Figure 4 are used for the conversion from Digital Numbers (DN) to Radiance and Radiance to Temperature.

3.2   Stage 2- Creating Geodatabase of UHI-Spot

Corrected topographical map are digitized using ArcGIS software to create digital vector data of contour, land use, city, residential area and other layers. Contour is processed into TIN for displaying it in 3D perspective and visualization

3.3   Stage 3-Development of Green City in the UHI-Spot

Green city base map or master plan is prepared using Google Earth and SketchUp. This stage is essential in planning and building the suitable concept used for the proposed green city and 3D model in Shah Alam (Figure 5).
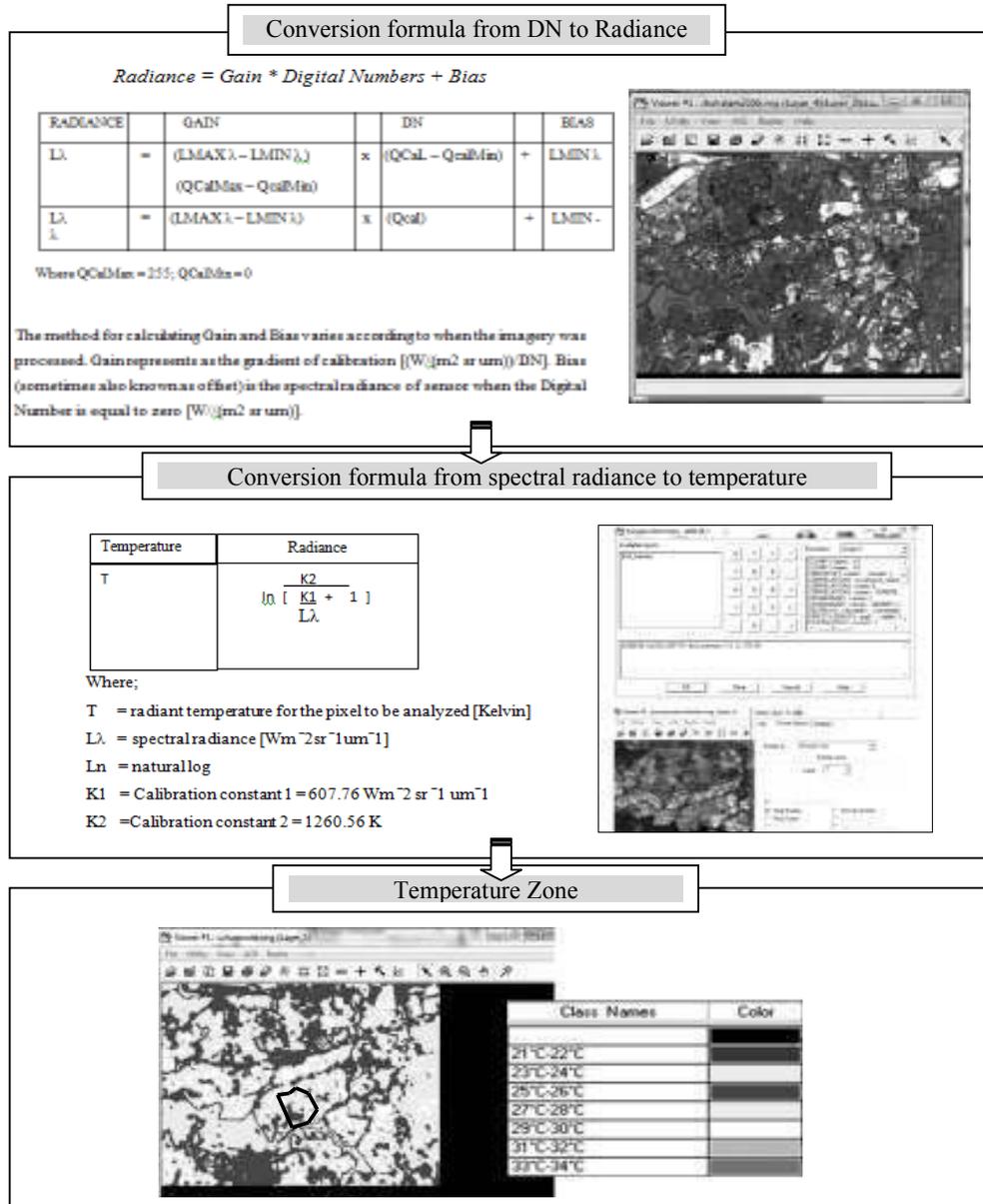

Figure 4: Flow Chart of Temperature Zoning and Mapping in Shah Alam 2006 Using Remote Sensing Techniques
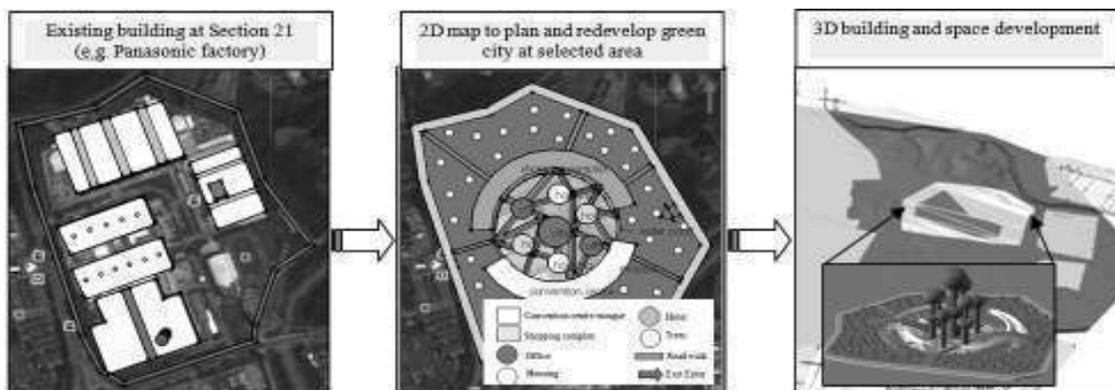

Figure 5: Conceptual Flow Chart for Shah Alam Green City Development in UHI-Spot

4.   Result and Analysis

4.1   *Urban Heat Island (UHI)-Spot in Shah Alam*

Based on the satellite land surface temperature, the highest temperature in Shah Alam is recorded in Section 21 surrounding the Panasonic factory. The location is an industrial area that produces air conditioners. The location is void of trees and vegetation to utilize the carbon dioxide emitted from the factory. It is also in the transportation hub whereby lorries, buses, cars and motorcycle emitted a lot of carbon monoxide in the air. The area is very hot due to heat reflected from the factory which was built from metal and zinc materials.
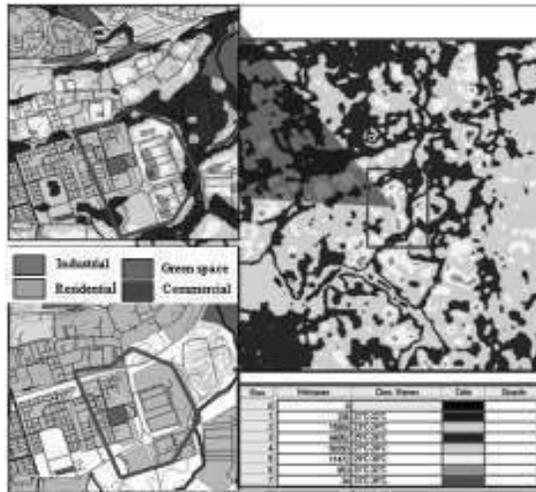

Figure 5: Satellite-Urban Heat Island-Spot in Shah Alam, 2006

4.2   *Proposed Development of Green City in Shah Alam*

Based on the location analysis conducted at the site (Figure 7), it needs to develop a housing estate, mosque, green space, shopping complex and any green space requiring the element of green town in Shah Alam. The concepts of the selected green city index and Malaysian tropical forest are also applied to moderate the effect of UHI in the study area and towards a sustainable development in Shah Alam known as 'Bandaraya Anggerik'.
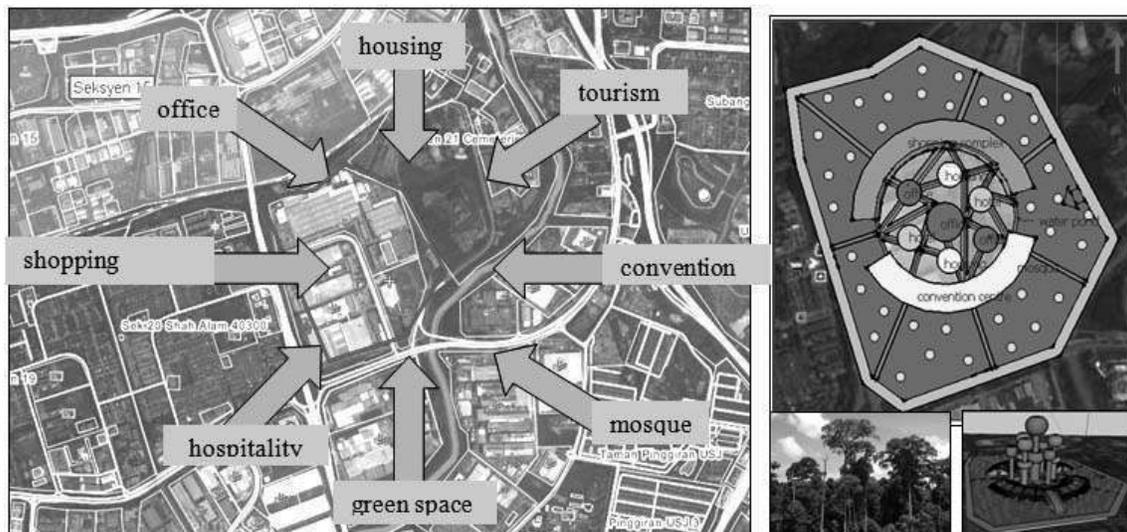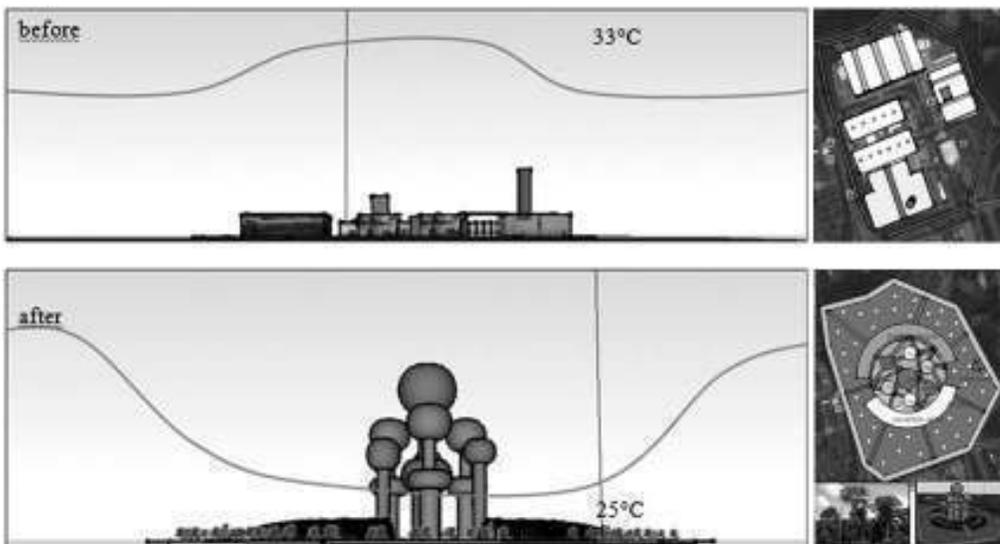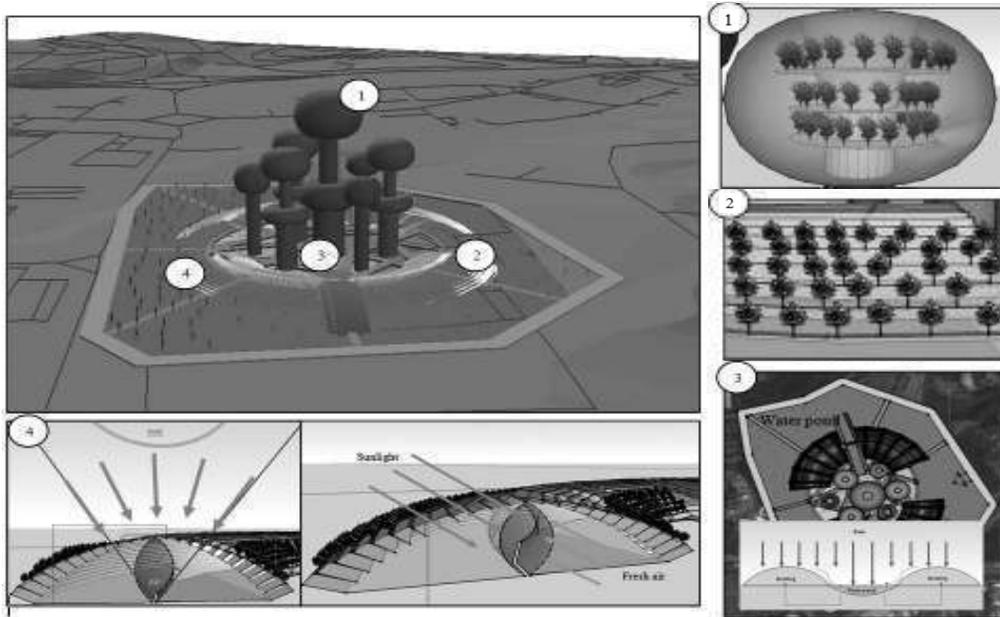

Figure 7: Location Analysis in Section 21, Shah Alam.

4.3   Geovisualization of Simulation Green City in Shah Alam

From the combination of ArcScene in ArcGIS and Google Sketchup, a 3D geovisualization can be viewed as shown in Figure 8. The 3D geovisualization is important to monitor and predict natural events such as flash flood, erosion, traffic transportation network and so on. The green concept applied in this study is to reproduce oxygen (1,2), recycle water (3), renew solar energy and lighting and fresh air (4). Simulation results and effects of proposed green elements in building could be moderating UHI-spot towards a green city in Shah Alam as illustrated in Figure 9.

Figure 8: Applying Green Elements in Developing a Proposed Green Area in Section 21, Shah Alam

Figure 9: Simulation Effects of Urban Heat Island before and after Proposed Green Development in Section 21, Shah Alam

5.   Conclusion

The combination of geovisulization, green city index and location analysis can simulate a proposed green area in Shah Alam. Three main stages applied in this study are determining urban heat island (UHI)-spot, creating geodatabase of UHI-spot, and development of simulation a green city in UHI-spot of Shah Alam. Satellite land surface temperature and GIS-based map show urban heat island-spot in Shah Alam mainly at Section 21. The site analysis suggests a housing estate, mosque, green space, shopping complex and other green elements to be implemented in the study area for cooling the effects of UHI towards a green city in Shah Alam. The results shown in this study are only simulation planning in Shah Alam using qualitative method. The result could be improved by applying updated and higher resolution satellite images and conducting *in-situ* observation at the study area.

Acknowledgement

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