LAND MANAGEMENT & ITS EFFECTS ON INTENSITY OF THE URBAN HEAT ISLAND: A CASE STUDY ON CITY OF KUALA LUMPUR, MALAYSIA

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ABSTRACT
The study aims to find the effects of land management on the intensity of the urban heat island through a case study done on the city of Kuala Lumpur, Malaysia. Two methodologies combined to study the urban heat island of the city; Weather Station Networks Method and Traverses Survey Method in December 2004. The study used the Geographic Information System (GIS) technology to establish the colored contour maps of the urban heat island of the city. The study shows that, there is an increase in the intensity of the urban heat island of the city of Kuala Lumpur since last similar studies done in 1985. The increase in the intensity of the urban heat island of the city is 1.5 ^{o}C. On the other hand, there is a remarkable change in the land use of the city of Kuala Lumpur since 1980 to 2004. The study shows that, while the intensity of the UHI of the city increased, the open space and recreational, residential, institutional, undeveloped and agricultural/ fishery/ forest lands of the city decreased. Conversely the commercial, , road and rail reserves, cemetery, and educational lands increased. Thus, the study concludes that, the intensity of the Urban Heat Island (UHI) of the city of Kuala Lumpur is proportional to the commercial, road and rail reserves lands and inversely proportional to the open space and recreational, residential, institutional, and agricultural/ fishery/ forest lands. The study concludes that, the land management play an effective role in the intensity of the urban heat island. The more open spaces, recreational and agricultural/ fishery/ forest land the less intensity of urban heat island.

KEY WORDS
Land, Management, Urban, Heat, Island, Malaysia.

1. Introduction

In many developing countries, towns are expanding and an increasing proportion of the land is being taken up for urban land uses, replacing fields, farms, forests and open spaces. As a result, distinctive and often unpleasant climatic conditions are experienced by the majority of urban inhabitants in the world today (Shahrulddin Ahmad 1997[1]). Urban settlements provide one of the best examples of change in human activities and perceptions. Residential areas are constantly undergoing modification and expansion into areas that were formally occupied by agriculture and the natural environment. Residential lands were reclaimed or will be reclaimed from the sea or swampland if the demand for land is sufficiently high.

Large urbanized regions have been shown to physically alter their climates in the form of elevated temperatures relative to rural areas at their periphery (Brian, 2001[2]).The effect of metropolitan regions is not only confined to horizontal temperatures but also to those in the vertical direction with far-reaching consequences, studies have shown that the thermal influence of a large city commonly extends up to 200-300 m and even to 500 m and more (Sham Sani, 1993 [3]). Sham (1987) [4] mentioned that, his studies at Universiti Kebangsaan Malaysia over 12 year's period indicate that the commercial centers of Kuala Lumpur are usually several degrees warmer than the surrounding countryside, which is a phenomenon known as the heat island.

The increased size of urban areas in terms of their population and their land consumption has intensified adverse urban environmental impacts. The increased capacity of the human race provokes adverse environmental change on a truly global scale. The 1996 Environmental Quality Report (DOE, Malaysia) notes that almost all aspects of the environment have been affected by development activities and changes on land use. Heat island is one of the many areas of deterioration of the environment due to development and changes due to human activities. This study discusses the urban heat island of the city Kuala Lumpur, Malaysia and aims to find the effects of the land management on the intensity of the urban heat island of the city.

2. Methodology

The data relative to the land management of the city of Kuala Lumpur is gathered from Malaysian Governmental

sources and specifically from the City Hall of Kuala Lumpur City. On the other hand, there are two major sources of data used to study the UHI of the city; Secondary and Primary sources of data. The Secondary data is collected from the relatively longer records of meteorological data provided by specific weather station networks, while the Primary data is collected through an intensive fieldwork done with the collaboration of a number of assistants and field observers. Alternative methodologies are used for the collection of those primary and secondary data. These two methods are combined and used to study and measure the urban heat island of the case study, City of Kuala Lumpur:

2-1- Measuring the urban heat island through weather station networks

Two weather station networks cover the City of Kuala Lumpur and its periphery; Governmental weather station network and private one. According to the case study, a specific number of stations are selected to be involved in the study. Concerning the first weather station network, which is under Malaysian Ministry of Science and Environment and called the Malaysian Meteorological Services (MMS), the stations selected to be used are: Kuala Lumpur International Airport (KLIA), Petaling Jaya, Subang, Sungai Besi, and University Malaya. While for the private weather station network, the stations selected are: Combak, Shah Alam, Cheras, Contry Height, Klang, Nilai, and Petaling Jaya.

2-2- Measuring the urban heat island through traverses surveys

This method is used in a specific confined area within the study area for this research. It was used for the city center of Kuala Lumpur city and four major Gardens within Kuala Lumpur and its periphery, and that because of the lake of weather station in those areas. Moreover, within the city center of the city no weather station is located. The area was confined not only because of lack of data in that areas, it is moreover because of equipments and financial constraints that faced the authors during that period.

Because of the difficulty of making simultaneous measurements, a number of eighteen observers took measurements and readings. They are senior undergraduate students from College of Architecture and Environmental Design and College of Engineering, International Islamic University Malaysia. With the help of these observers, an intensive traverse surveys were carried out for measuring the air temperature, relative humidity and air velocity during one week period in December 2004, starting in 20th of the month and end by 26th for one-hour duration per day from 21:00-22:00 Local Malaysian Time (LMT).

Concerning this traverse Surveys; the study area is divided into several sectors. Each sector is assigned to one or two observers according to the area and complexity of sector referring to the aim of the research.

3- Results and Analysis

3-1- Land management

From charts 1, 2 & 3 below, there is a tremendous change in the residential, commercial, open space and recreational, road and rail reserves, and undeveloped land use of the city from 1980 to 2004. The residential and undeveloped land use of the whole city both decreased from 25.7% to 22.66% and from 27.7% to 23.7% respectively. Under the undeveloped land use the agricultural/ fishery/ forest land use is categorized. There is a recognized decrease in the agricultural/ fishery/ forest land use. By 2004 it occupied only 0.07% (16.13 acres) of the total area of the city. Conversely, the commercial, open space and recreational, and road and rail reserves land increased from 2.1% to 4.51%, 1.3% to 6.52%, and from 14.0% to 23.42% correspondingly. Almost there is no change in the industrial, institutional, cemetery, and educational land use of the whole city. The industrial and institutional lands decreased from 2.3% to 2.28% and from 7.2% to 6.69% respectively. While the cemetery, and educational lands increased from 3.3% to 3.98% and from 1.1% to 1.13 %respectively.

The changes in the land use of the city center are almost following the same manner of the city of Kuala Lumpur. The commercial, road and rail reserves land increased from 254.88 to 318.99 hectares and from 498.69 to 566.68 hectares respectively. While the residential, industrial, and institutional land use reduced from 390.58 to 287.6 hectares, from 4.12 to 0.93 hectares, and from 266.04 to 163.06 hectares correspondingly. In converse to the city increase in the open space and recreational land use, the city centre open space and recreational land use decreased from 179.28 to 170.25 hectares. While the undeveloped land use of the city center increased from 0.0 to 137.89 hectares.

3-2- Urban heat island

From Table 1 below, the highest temperature in 1985 and 2004 is located and recorded within the city centre of the city. Nevertheless, it is increased by an amount of 1.5 degree Celsius. On the other hand, the lowest temperature is located and recorded outside the city centre area.

This study shows that, there are many heat and cool islands located within the study. However, most of these heat islands are located within the city center, while most of the cool islands are located away from the city centre of the city. It shows also that, the number of heat islands detected during the survey is six. Five out of these six heat islands are located within the city centre of the city; Puduraya, Bukit Bintang, Times Square, KLCC, and Chow Kit stations. While the sixth heat island is Petaling Jaya (MMS) which is located outside the city of Kuala Lumpur and in its periphery. Therefore, it is concluded from this study that, the city centre of the city is the

hottest area compared to the rest of Kuala Lumpur Metropolitan Region, which support the previous findings from the earlier works of similar studies. On the other hand, the study shows that, the cool islands detected during the survey are located in and around Main Lake Garden, Cheras, Petaling Jaya (ASMA), University Malaya, Gombak, Country Heights, and Nilai stations. The results of this study indicate that, Petaling Jaya station is recorded as the coolest island. And both Gombak and Country Height stations are the second coolest island, where both of them are located outside the city of Kuala Lumpur. It moreover finds that, there is only one cool island located within the city centre of the city that is the Main Lake Garden station, while the rest of these cool islands are located away from the city center of the city. Furthermore, three of these cool islands are located outside the city of Kuala Lumpur with relatively low temperatures. Consequently, these findings emphasize the general theory of the urban heat islands that assume rural and suburban areas as cooler than that of urban areas. The literature reviewed (Ahmad Faud bin Embi and Norlinda Binti Mohd Dom 2004[5]; Hafner J. 1996[6]; Hoong Y. Y. and Sim L. K. 1984[7]; Shashua-Bar & M. E. Hoffman 2000[8]; Orville R. E. et al. 2001[9]; Shaharuddin Ahmad 1997; Shahruddin Ahmad and Norazizah Ali. 1997[10]; Sham Sani 1987, 1990/1991[11], 1993; Smoyer K. E. 1997[12]; Streutker D. R. 2003[13]; Valazquez-Lozada 2002[14]; Wan Mohd Naim Wan Mohd and Abdul Malek. M. 2004[15]) also confirms this findings, indicating that the temperature in city centers are in general high when compared to that which were recorded in fringes of cities, suburban areas and rural areas. The study concludes that, the theory above is valid for the results gained from this work excluding Petaling Jaya ASMA station, which required more detection, elaboration, detailed explanation on the characteristic of the site as a further study.

The nucleus of the UHI of the city in the previous studies was located within the city center of the city; recently the study shows that, it is also located within the city center. Nevertheless, the location of the nucleus has shifted. It was previously located in Chow Kit area, now the study shows that, it is located in Puduraya area.

Looking at both land management of the city of Kuala Lumpur and the intensity of the urban heat island of the city, it is obvious that, the intensity of the UHI of the city increased the residential, industrial, institutional, undeveloped and agricultural/ fishery/ forest lands decreased. Conversely the commercial, open space and recreational, road and rail reserves, cemetery, and educational lands increased. In addition to that, as the city centre get warmer and its temperature increased its commercial, undeveloped, road and rail reserves land increased, while its open space and recreational, residential, and institutional land decreased.

The study finds that, all gardens and parks have relative low temperatures regardless of their locations, in or outside KL. Furthermore the lowest temperature is recorded for a station located within the city centre of the city, which is the Main Lake Garden station. That is because of the age and area of the garden compared to other gardens included in the study. The Main Lake garden is the largest lake park in the city (Hamidah Sudin et al., 1990[16]). This garden dates back to the 1890s with an area of 73 hectares. While Titiwangsa Lake garden is the second lake park in the city with an area of 44.5 hectares. The garden is even different from other gardens in terms of its type and age of plants.

Recent study by Elsayed, I. S. (2006) [17] shows that, although the dependence of the intensity of the urban heat island of the city of KL on population density is significant, the population density at the city centre area is decreasing. It might be of interest to urban planners that, although the temperature is likely to rise with the increase of population density, the situation at the city centre is different. This is due to the intensive human activity and development within the city centre of KL. That indicates that, the management of those lands is highly affecting the intensity of the urban heat island of such land. The city centre experiences rapid changes in concentration of commercial activities and constructions. Man through his constructions has affected the exchange of energy and moisture within the system by altering the physical qualities and materials of the earth's surface with in the city centre. The city centre has been occupied by multi stories and very tall buildings (e.g. Petronas Twin Towers). These multi-storied buildings found in the city centers dominate the skyline, and have a dramatic effect on the microclimates of the city centre. Man replaces vegetation and greenery by buildings and becomes a primary source of heat produce from transportation systems, industrial plants, and HVAC systems. Therefore, the city centre is still the hottest area of the city of Kuala Lumpur regardless of the reduction happened in its population density. This fact should help in convincing urban planner and design makers in placing more emphasis on the strategies that relates the land management to the mitigation of urban heat island.

4.1 Charts and Tables

Chart 1: Land use in percentage for city of Kuala Lumpur in 1980

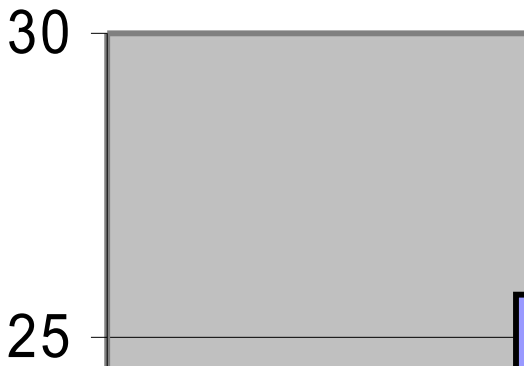

Chart 2: Land use in percentage for city of Kuala Lumpur in 2004

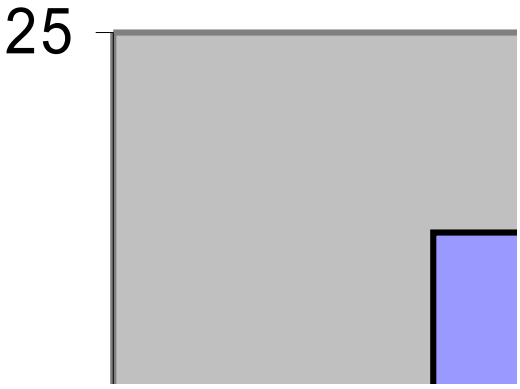

Chart 3: Land use in Hectares for the city center of Kuala Lumpur in 1984 & 2004

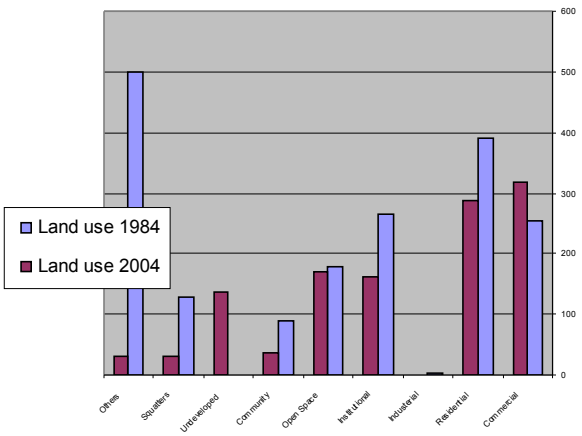

Table 1: Intensity and location of the UHI of the city of Kuala Lumpur in 1985 & 2004

Year	UHI Intensity (°C)	Highest Temperature (°C)	Location of highest temperature	Lowest Temperature (°C)	Location of lowest temperature
1985	4.0	28.0	City centre & locations bounds the city centre	24.0	Outside city centre (fringes of KL city)
2004	5.5	28.6	City center (Puduraya)	23.1	Outside city centre (Petaling Jaya ASMA & Country Height)

5. Conclusion

The study concludes that, the commercial, road and rail reserves lands of the city is proportional to the intensity of the UHI, while the open space and recreational, residential, institutional, and agricultural/ fishery/ forest lands is inversely proportional to the intensity of the UHI of the city.

From the research findings and literature reviewed the study concludes that, the intensity of the urban heat island could be reduced if the land of the city of Kuala Lumpur managed in such ways below:

- Trees should be planted to shade the hot tarmac of city roads or at least low-level bushes and greenery. Within the city of KL, Many open areas are covered with blocks of marble, granite or tiles. Although these are better than black tarmac, these areas still absorb a lot of heat in direct sunlight and release the heat at late afternoons, evenings and early nights. Again, the author recommends that, such open areas should be turned into green areas or even very small parks. Further more, trees should be planted to shade the hot tarmac of inner city roads like Jalan Tuanku Abdul Rahman, Chow Kit…etc; or low level bushes planted along the covered drains in such areas. In addition to that, some roads and highways, which take up an increasing proportion of the urban area, should also be creatively designed to include green shade. The large masses of concrete in new flyovers that are continuously being built all over the city, capture and store large quantities of solar heat, should also take into consideration some plant cover, like overhanging creepers which can shield or block absorption of the heat and reduce the air temperature significantly.
- Roads and highways, which take up an ever-increasing proportion of the urban area, should also be

creatively designed to include green shade, at the very least along the medians. The large masses of concrete in new flyovers continuously being built all over the city, which can capture and store large quantities of solar heat, should also take into consideration plant cover, like overhanging creepers which can shield or block absorption of the heat.

- Urban car parks should comply with a minimum of 50% shade requirement. Studies (Eliasson 1993[18]; Shashua- Bar L. & Hoffman M. E. 2000[19]; Sham Sani 1987, 1990/1991) show that shade trees contribute significantly to temperature reduction, hence the reduction on the intensity of the UHI. Therefore, the author suggests that, urban car parks should comply with a minimum of 50% shade requirement by plantation of trees or/and low level bushes.
- Tree planting programs should be reintroduced for all housing estates. Incentives and subsidies should be part of the long term planning.
- Many commercial buildings, almost all (Ahmad Faud B. Embi & Norlinda Bt. Mohd. Dom 2004) are having flat roofs in Malaysia either to accommodate air-conditioning equipment or water tanks, or for another purposes. Such buildings should green their roofs and planted them with shrubs and low level bushes. This means cultivating greenery on the flat roof surfaces to absorb the heat. This will not only help the city to counter UHI but building owners will also benefit in terms of savings in air-conditioning power consumption. As proven in previous studies; please check chapter 2 for more details.
- Studies (Eliasson 1993; Shashua- Bar L. & Hoffman M. E. 2000; Sham Sani 1987, 1990/1991) proved that green areas moderate urban temperatures. The results of this study confirm this theory, it shows that, the green areas are relatively low in temperature than the non-green areas. The creation of as many cities parks as possible will improve the situation and help significantly in reducing the intensity of the UHI of the city. Therefore, tree planting programs should be reinforced in the city of KL, and incentives and subsidies should be part of the long term planning for the city.
- Reduce summer solar radiation by managing the land covered by critical surfaces, for example, pedestrian walks, waiting areas, and busy streets. Reduce the abundance of concrete and asphalt, and increase the amount of vegetation and open water. This will increase higher volumetric heat capacities and greater rates of latent heat influx, thereby lowering air temperatures.
- Increase airflow at ground level to flush heated and polluted air away from the city and that could be achieved by managing the land cover and building design.

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References

[1] Shaharuddin Ahmad, Urbanization and human comfort in Kuala Lumpur-Petaling Jaya, Malaysia, *Ilmu Alam, 23,* 1997, 171-189.

[2] Brain S. J., *Remote Sensing Analysis of Residential Land Use, Forest Canopy Distribution, and Surface Heat Island Formation in Atlanta Metropolitan Region,* Ph. D. Thesis, Atlanta, Georgia Institute of Technology, 2001.

[3] Sham Sani, *Environment and Development in Malaysia: Changing Concerns and Approaches* (Malaysia: ISIS Malaysia, 1993).

[4] Sham, Sani, *Urbanization and the atmospheric environment in the low tropics: Experiences from the Klang Valley Region* (Bangi: Penerbit Universit Kebangsaan Malaysia, 1987).

[5] Ahmad Faud bin Embi & Norlinda Binti Mohd Dom, *Urban heat islands in Kuala Lumpur* (Kuala Lumpur: Department of Irrigation and Drainage Malaysia, 2004).

[6] Hafner J., *The Development of Urban Heat Islands in the Southeast Region of the United States in the Winter Season (Global Warming),* Ph. D. Thesis, Huntsville, University of Alabama, 1996.

[7] Hoong Y. Y. & Sim L. K. (eds.), Urbanization and ecodevelopment: with special reference to Kuala Lumpur, *Proc. of Seminar: PRO, 2,* Institute of Advance Studies, University of Malaya Press, Kuala Lumpur, 1984.

[8] Shashua-Bar L. and Hoffman M. E., Vegetation as a climatic component in the design of an urban street: An empirical model for predicting the cooling effect of urban green areas with trees, *Energy and Building, 31,* 2000, 221-235.

[9] Orville R. E., Enhancement of cloud-to-ground lightning over Houston, Texas, *Geographical Research, 28,* 2001, 2597-2600.

[10] Shahruddin Ahmad and Norazizah Ali, The essential usage of air conditioning system in Petaling Jaya, Selangor, Malaysia, *Proc. of Symposium on Population, Health and the Environment,* International Geographical Union Commission on Population and the Environment, Chiang Mai, Thailand, 1997.

[11] Sham Sani, Urban climatology in Malaysia: An overview, *Energy and Buildings Journal. No. 15-16*, 1990/91, 105-117.

[12] Smoyer K. E., *Environmental risk factors in heat wave mortality in St. Louis,* Ph. D. Thesis. Minnesota, University of Minnesota, 1997.

[13] Streutker D. R., *A Study of the Urban Heat Island of Houston, Texas.* Ph. D. Thesis, Taxes, Rice University, 2003.
[14] Valazquez-Lozada A., *Urban heat island effect analysis for San Juan, Puerto Rico,* M. Sc. Thesis, San Juan, University of Puerto Rica, 2002.
[15] Wan Mohd. Naim Wan Mohd. & Abdul Malek M., *Utilizing satellite remote sensing and GIS technologies for analyzing Kuala Lumpur's urban heat island* (Kuala Lumpur: Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, 2004).
[16] Hamidah Karim, (ed.), *Kuala Lumpur: the city of our age* (Kuala Lumpur: City Hall of Kuala Lumpur. 1984).
[17] Elsayed I. S., *The Effects of urbanization on the Intensity of the Urban Heat Island: a Case Study on the City of Kuala Lumpur,* Ph. D. Thesis, Kuala Lumpur, International Islamic University Malaysia, 2006.
[18] Eliasson I. K., *Urban Climate Related to Street Geometry, Ph*. D. Thesis, Goteborgs, Goteborgs Universitet, 1993.
[19] Shashua-Bar L. and Hoffman M. E., Vegetation as a climatic component in the design of an urban street: An empirical model for predicting the cooling effect of urban green areas with trees. *Energy and Building, 31,* 2000, 221-235.