ESTIMATING THE EFFECTS OF TRAFFIC HEAT REDUCTION THROUGH NEIGHBORHOOD GREENING METHODS IN A WORLD HERITAGE SITE - MALACCA, MALAYSIA

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ABSTRACT

Malacca city in Malaysia has been UNESCO-designated world heritage site. The area is feared that urban heat environment condition will gradually get worse in the future due to the lack of green spaces and anthropogenic heat from the surrounding areas. The study is aiming at estimating the effect of traffic heat reduction after implementing the neighborhood greening methods that has been developed in the preceding relevant researches. As a result, it is showed that the calculation procedures by combining the developed and stored spatial database worked effectively, and the amount of changes of traffic heat on each street and the whole study area objectively.

1. INTRODUCTION

Malacca city, located on the west coast of the central part of the Malaysian peninsula, has been designated as a UNESCO World Heritage Site. The city retains a large number of historical buildings and streetscapes in its center. However, from the viewpoint of the environment surrounding the designated area, green spaces are very limited in number and size, and most are separated from each other. In addition, chronic traffic congestion is caused by the continuous traffic through the narrow streets that have shaped the form of the town. Consequently, it is feared that urban heat environmental conditions will gradually worsen in future. For the purpose of sustainable conservation and improvement of the town as a heritage site sustainably in the future, it is expected that a new analysis and design approach will create organically linked neighborhood green spaces that will encourage people to walk around the area more actively through a modification of the surrounding heat environment. The overarching goal of the research project including this paper is creating a sort of a virtuous cycle (Fig. 1) in the future that an improvement of heat environment will promote people including tourists to walk more actively, and then it will contribute to reducing number of through traffic into the area, then it will lead to further amelioration of heat environment.

This study is aiming at estimating the effect of traffic heat reduction after implementing the neighborhood greening methods that have been developed and proposed in the preceding relevant researches. Firstly the traffic scenarios are prepared by combining main parameters such as street width, vehicle routing and vehicle type in accordance with the extent of urban heat amelioration on surrounding air temperature. Then, traffic heats on a whole study area and each street are estimated. Secondly the objective analysis is carried out in order to comprehend the effectiveness of heat reduction in where and how much it could be accomplished. Finally, the results obtained are summarized from the aspect of how much the proposed neighborhood greening methods could contribute to reduce traffic heat in the study area.

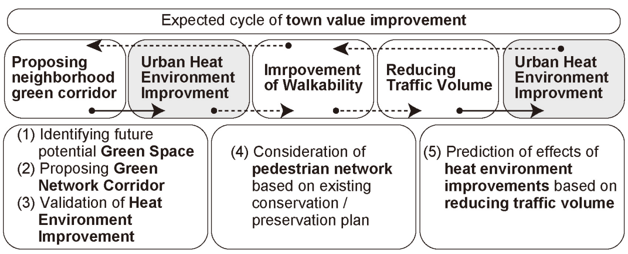

Fig. 1 Expected cycle of town value improvement

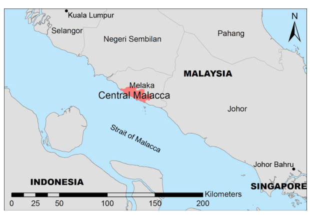

Fig. 2 Location of Malacca

Fig. 3 UNESCO-designated historical area

2. METHODOLOGY

2.1 Study Area

This study was conducted in the central area of Malacca, in Malaysia. The Malacca town is located on the west coast of Malaysia Peninsula and faced to the Strait of Malacca (Fig. 2). There have been inherited historical buildings and streetscapes which passing on diverse deferent cultures in the center area of the town, and these were registered the UNESCO World Heritage site in 2008. The registered heritage site encompasses two zones, which are the core zone (0.37 km2) and the buffer zone (1.69 km2). This study narrows down the target area to within 480×320 m including the Malacca River that flows through the town center (Fig. 3).

2.2 Relationship with Previous Relevant Researches

In order to achieve the purpose, the research refers and applies the results of previous relevant researches as a series of studies. The necessary underlying spatial database, and analytical tools and procedures for microclimatic simulation using computer simulations and visibility studies with Space Syntax theory were discussed and developed in Saito (2013). By combining the developed spatial database and analytical techniques, Saito (2015a) discussed the future potential greening area which could be expected to improve neighborhood walkability are identified through analytical approaches which combined three different perspectives: the urban heat environment, urban design/configuration, and existing development plans/directions. Saito (2015b) showed that the scenario-based neighborhood greening and proposing pedestrian walkways (Fig. 4) and effectiveness for urban heat environment amelioration based on through the comparative analysis (Fig. 5).

Fig. 4 Proposed neighborhood green corridor (Saito, 2015a)

2.3 Methodology for Estimating Traffic Heat

The traffic heat by streets in the study area will be estimated by referring to the traffic volume through the official traffic analysis done by local authority (Fig. 6). In here, the estimating methods for traffic heat developed by Japanese ministries (MILT and MOE, 2004) will be used as a reference. The main concepts of this method comprised the approaches that estimating

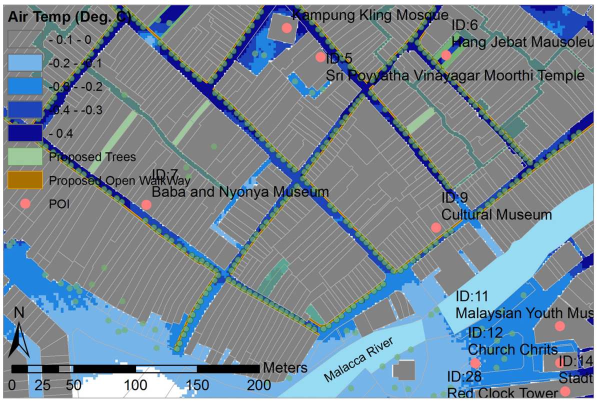

Fig. 5 Differences of air temperature between before and after implementing proposed methods (Saito, 2015b)

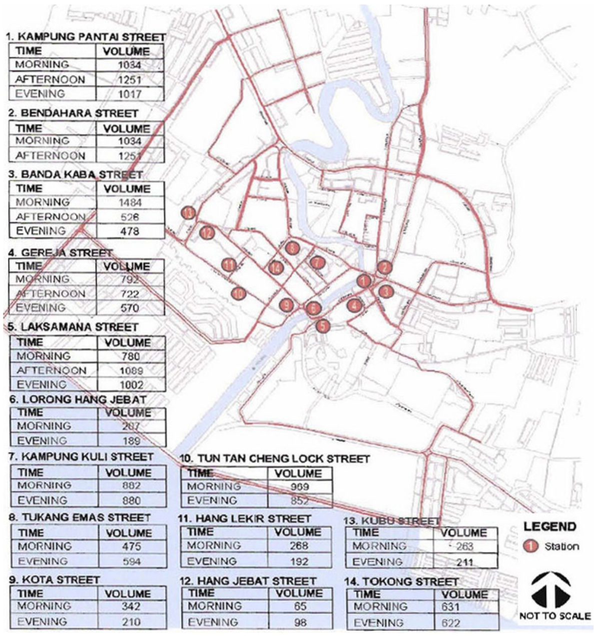

Fig. 6 Traffic volume through official analysis (Melaka Town and Country Planning Department, 2008)

overall traffic heat by multiplying a unit of consumption energy (based on each vehicle type and traffic speed) by travel distance by traffic speed. It is expected that this way could be applicable to Malaysia context in which Japanese car is widely used. However, it is necessary to be clearly stated as a constraint as followed:

- Official road traffic census or origin-destination survey is not obtainable in Malacca city.
- Setting of the number by type of vehicles is based on hypothesis through the investigation using videos and field survey done by authors.

3. ANALYSIS

3.1 Estimating Current Traffic Heat Condition

Firstly, the estimation of current traffic heat is carried out based on the result of traffic system shown in Fig. 6. The basic spatial information such as distance and width on 9 streets and hypothetical traffic volume by daytime-nighttime and by type of vehicles is shown in the Table 1. In here, the traffic speed in the study area is set to 20 km/h. All the calculation after this section is carried out on the basis of this basic information. The energy efficient (HHV: High Heating Value, LHV: Low Heating Value at 20km/h traffic speed) is needed to refer to the MILT and MOE (2004) for more detailed about equation and those calculation procedures.

The consumption energy from vehicles is estimating by multiplying energy coefficient by number of vehicles (by type) by travel distance (Table 1). Additionally, exhaust heat form air-conditioner is also derived from the differences of fuel consumption between using and not using car air-conditioner by taking into account of engine energy efficiency and air-conditioners' COP (Coefficient of Performance). As a result, the traffic heat to surrounding environment in the study area using car air-conditioner is estimated as shown in Table 2.

The result as shown in Table 3 describes that the estimated traffic heat on each street. Those results are also stored in GIS as one of the spatial database and are used as a basis on scenario making by overlaying with other stored layers for instance shown as Fig. 7.

3.2 Making Scenario for Traffic Heat Reduction

As a next step, the scenarios for traffic volume reducing are prepared in accordance with the extent of urban heat reduction after implementing neighborhood greening methods (Fig. 4) by combining current traffic heat (3.1) and the result from preceding research (2.3). Then, applying same calculation methods as 3.1 based on the scenarios carries out the estimation of the extent of traffic heat reduction by each street.

Fig. 8 shows that the composite map which encompasses the reclassified map on new three classes (High, Moderate, and Low) in accordance with the extent of surrounding air temperature reduction (Fig. 5) and the current traffic heat map indicating on each street (Fig. 7). In here, the scenarios of traffic volume reduction are prepared on the hypothesis that the extent of urban heat amelioration (surrounding air temperature reduction) is contributing to increase walkability and decrease traffic volume in the study area. Scenario 1 is made up of [Class M: 10%, Class H: 25%] contributes to traffic reduction, and Scenario 2 is more actively [Class M: 25%, Class H: 50%]. Here, only 'private car' and 'bus', which is considered as drivers to contribute to increasing volume of pedestrian, out of 4 types of vehicles is focused on. In addition to those scenarios, the optional guideline that zone A and B on two respective streets in Figure 8 turns into car-free zone are prepared. By combining those scenarios and guideline, the extent of traffic heat reduction is estimated and analyzed. As a justification for the guideline above, the zone A (Fig. 9, Approx. 100 meters in distance) is already proposed as a car-free zone in the existing conservation area plan, and the zone B (Fig. 10, Approx. 135 meters) has only 5.8 meter width and almost no spaces for pedestrian blocked by illegal on-street parking and heavy through traffic even though the area indicates high potential for urban heat reduction in Fig. 8.

Table 2 Amount of total traffic heat in the study area

	Private Car	Bus	Small Lorry	Normal-Sized Lorry	Total
Sensible Heat (A)	6.8	4.5	1.0	1.6	13.8
Latent Heat (B)	0.1	0.2	0.0	0.1	0.5
Total Traffic Heat (A) + (B)	**6.9**	**4.7**	**1.1**	**1.7**	**14.3**

(GJ/day)

Table 3 Current traffic heat on each street (GJ/Day)

Street Name	StreetNo	Traffic Heat by Street
Jalan Tun Tan Cheng Lock (Heeren Street)	10	4.3
Jalan Hang Jebat (Jonker Street)	12	0.4
Jalan Tokong/Tukang Emas	8	0.7
Jalan Kamung Kuli	7	1.1
Jalan Kampung Pantai	1	1.3
Lorong Hang Jebat	6	0.7
Jalan Laksamana	5	4.4
Jalan Hang Lekir	11	0.4
Jalan Tokong	14	0.5

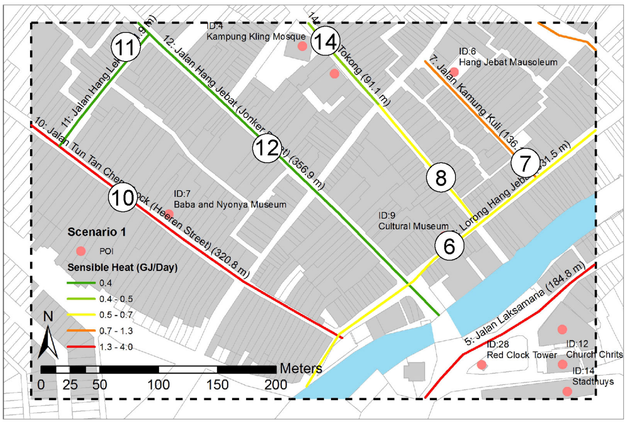

Fig. 7 Traffic heat on each street in GIS database

Table 1 Street basic information and hypothetical vehicles type distribution

				Hypothetical Distribution by Street				Number of type of vehicle (Daytime)					Number of type of vehicle (Nighttime)				
Streets	St. ID	Width (m)	Distance (m)	Private Car	Bus	Small Lorry	Normal-sized Lorry	Private Car	Bus	Small Lorry	Normal-sized Lorry	Total	Private Car	Bus	Small Lorry	Normal-sized Lorry	Total
Jalan Tun Tan Cheng Lock (Heeren Street)	10	9.0	320.8	**65%**	**20%**	**10%**	**5%**	630	194	97	48	**969**	554	170	85	43	**852**
Jalan Hang Jebat (Jonker Street)	12	9.0	356.9	**70%**	**0%**	**20%**	**10%**	46	0	13	7	**65**	69	0	20	10	**98**
Jalan Tokong/Tukang Emas	8	7.5	130.7	**90%**	**0%**	**10%**	**0%**	428	0	48	0	**475**	535	0	59	0	**594**
Jalan Kamung Kuli	7	5.8	136.1	**90%**	**0%**	**10%**	**0%**	794	0	88	0	**882**	792	0	88	0	**880**
Jalan Kampung Pantai	1	20.0	55.0	**65%**	**20%**	**10%**	**5%**	1485	457	229	114	**2285**	661	203	102	51	**1017**
Lorong Hang Jebat	6	6.5	331.5	**90%**	**0%**	**10%**	**0%**	258	0	29	0	**287**	170	0	19	0	**189**
Jalan Laksamana	5	12.0	184.8	**55%**	**30%**	**10%**	**5%**	1028	561	187	93	**1869**	551	301	100	50	**1002**
Jalan Hang Lekir	11	9.5	121.9	**70%**	**0%**	**20%**	**10%**	188	0	54	27	**268**	134	0	38	19	**192**
Jalan Tokong	14	9.0	91.1	**90%**	**0%**	**10%**	**0%**	568	0	63	0	**631**	560	0	62	0	**622**

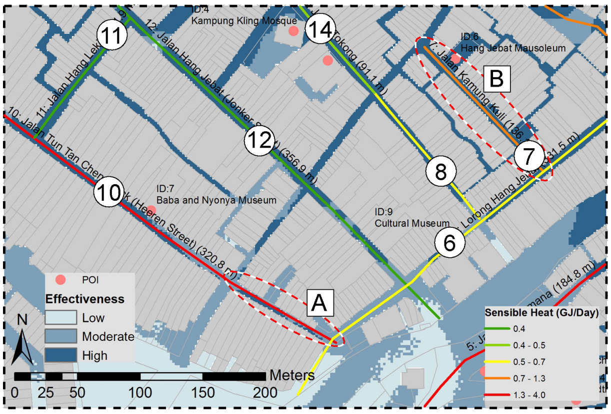

Fig. 8 Current traffic heat by street with effectiveness of air temperature reduction (3 classes)

Fig. 9 Zone A on ID 10 (Ref. Fig. 8)

Fig. 10 Zone B on ID 7 (Ref. Fig. 8)

3.3 Results of Scenario-Based Simulation

Table 4 shows that the results of estimation of traffic heat reduction by applying same procedure as 3.1 with two scenarios and guidelines. The following things could be highlighted based on the changes in value:

Table 4 Results of scenario-based traffic heat changes

Street Name	St. ID	Class	Scenario 1	Scenario 2	Scenario 1 + Guideline	Scenario 2 + Guideline
Jalan Tun Tan Cheng Lock (Heeren Street)	10	M	-8.0%	-19.9%	-36.9%	-45.1%
Jalan Hang Jebat (Jonker Street)	12	M	-5.2%	-13.1%	-5.2%	-13.1%
Jalan Tokong/Tukang Emas	8	H	-22.5%	-45.0%	-22.5%	-45.0%
Jalan Kamung Kuli	7	H	-22.5%	-45.0%	-100.0%	-100.0%
Jalan Kampung Pantai	1	-	-	-	-	-
Lorong Hang Jebat	6	M	-9.0%	-22.5%	-9.0%	-22.5%
Jalan Laksamana	5	-	-	-	-	-
Jalan Hang Lekir	11	H	-13.0%	-26.1%	-13.0%	-26.1%
Jalan Tokong	14	H	-22.5%	-45.0%	-22.5%	-45.0%
		Total:	**-7.2%**	**-15.9%**	**-22.4%**	**-28.1%**

- By looking at a whole study area, 7.2% and 15.9% traffic heat reduction can be seen by applying Scenario 1 and Scenario 2 respectively.
- On the street ID 12, which is one of the main streets, only 5.2% reduction can be seen because of low traffic volume based on the investigation (Table 1).
- On the street ID 7, 8, and 14, which is minor streets but with forming important historical streetscapes, the high percentages of reduction can be seen. It indicates that reducing traffic volume have grate effect to decreasing traffic heat even though its distance is short.
- On the street ID 10, which is one of the main streets and has heavy traffic volume of tourist bus, after turned the part of the street into a car-free zone, it is expected that the guideline could contribute to great effect of traffic heat reduction in spite of the distance is only approx. 100 meters.

4. CONCLUSION

Through the study, the estimation of changes of traffic heat based on the several scenarios and guideline for reducing traffic volume is carried out after implementing the neighborhood greening methods developed in the relevant researches. Although there are several constraints with regard to the lack of initial input traffic data, and the rational of relationship between the extent of urban heat amelioration and the extent of improving walkability, reduction of traffic volume are theoretically not clear enough, it became clear that the extent of changes of traffic heat in the whole study area as well as each street objectively and the procedures to analyze the effects of urban heat reduction through the neighborhood greening methods worked effectively. In the future, more accurate and detailed analysis on urban heat amelioration can be expected by applying an official wide-range road traffic census and advanced technical knowledge through further study about relationship between pedestrian walkability and traffic volume.

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