Track 4: Innovations Driving for Greener Policies & Standards

Session 1.6 Innovations Driving for Greener Policies and Standards – Microclimate

The Potential of Applying Local Climate Zone for the Sustainable Planning in Urban Built Environment

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ABSTRACT

*I*nspired by the increasing urbanization and urban heat island effect (UHI) issues, an innovative concept called Local Climate Zone (LCZ) was developed to standardize and classify various built environment. The LCZ system was use to evaluate the relationship between UHI and urban characteristics which included land cover, sky view factor (SVF), building height, surface albedo and roughness. Due to the previous research had revealed the LCZ system were highly related with the micro-climate condition, this work attempt to apply the LCZ into consideration of adapt the sustainable planning in urban built environment by comprehend the relevance between the thermal load and the LCZ distribution. The Tainan city was selected to be the study area because of the growing thermal stress and the reduction of ventilation path in the rapid urban development. In term of the LCZ classify method, the World Urban Database and Portal Tool (WUDAPT) was applied through the Landsat satellite image to make a wild range LCZ distribution map in an efficient way. In this study, there are two main issues discussed in the study. Firstly, to identify the LCZ by several methods and confirm if it is correct in reality. Secondly, to propose a method to quantify the thermal conditions in different LCZs in the urban area. The analytical results indicated that the WUDAPT may overestimate the building height compared to the actual height by the building digital map. It may due to the resolution in the satellite image is insufficient and the areas with small amounts of tall buildings will be still regards as compact high-rise areas. Concerning the thermal conditions in various LCZ, it is obvious that the highly developed urban areas, such as LCZ2 (Compact mid-rise) and LCZ3 (Compact low-rise) have a higher thermal stress distribution, while the natural areas such as LCZ 6 (Open low-rise), LCZ 9 (Sparsely built), got lower PET value based on the measured data. The result will contribute to the urban climate study and benefit to the sustainable development in the urban areas.

Keywords: *local climate zone, WUDAPT, thermal conditions*

1. INTRODUCTION

In the urbanization process, the thermal environment of cities has greatly changed due to the reduce of green area and the increase of buildings (Kent, 2011). Urban areas are generally warmer than their rural counterparts. This urban-rural temperature difference is known as urban heat island effect (UHI). Recently, global warming has exacerbated the phenomenon of UHI and threatening the health of urban dwellers. As urbanization is a long-term global trend, understanding how land development is associated with thermal environments becomes an important task for governments to adapt cities to hotter and longer summer.

Previously studies regarding thermal environment distribution in urban areas is highly related to the land use and land cover of the areas, and connected to urban morphology and building typology. However, there are many information required and should be prepared before the analysis. Therefore, this research uses an innovative method called Local Climate Zone (LCZ) (Stewart and Oke 2012) to substitute the traditional land zoning system which was developed for managing land resources by dividing land into various types, such as commercial, residential, and agricultural zones. Furthermore, LCZs can be classified into 17 basic categories, based on ten parameters, including sky view factor, aspect ratio, building surface fraction, pervious surface fraction, and

impervious surface fraction, height of roughness element, class of terrain roughness, surface admittance, surface albedo, and anthropogenic heat output.

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2. Method

2.1 Study area

As a high development city (22˚59'N, 120˚11'E) in the south of Taiwan, Tainan is selected to be the study area (Figure 1). The total area of Tainan is 175.6465 km2, including 6 administrative districts. In 2010, Tainan city had been upgraded to a special municipality. However, this transformation results the increase of population and land operations, make it urgently and necessary to consider of microclimate research in order to give local government assistance by making urban development policies. The Tainan city is in tropical areas, the annual mean temperature in this area is 24.6°C. July is the hottest month; the mean temperature is 30.4°C, January is the coldest month; the mean temperature is 17.6°C, and the annual mean relative humidity is 74.4%.

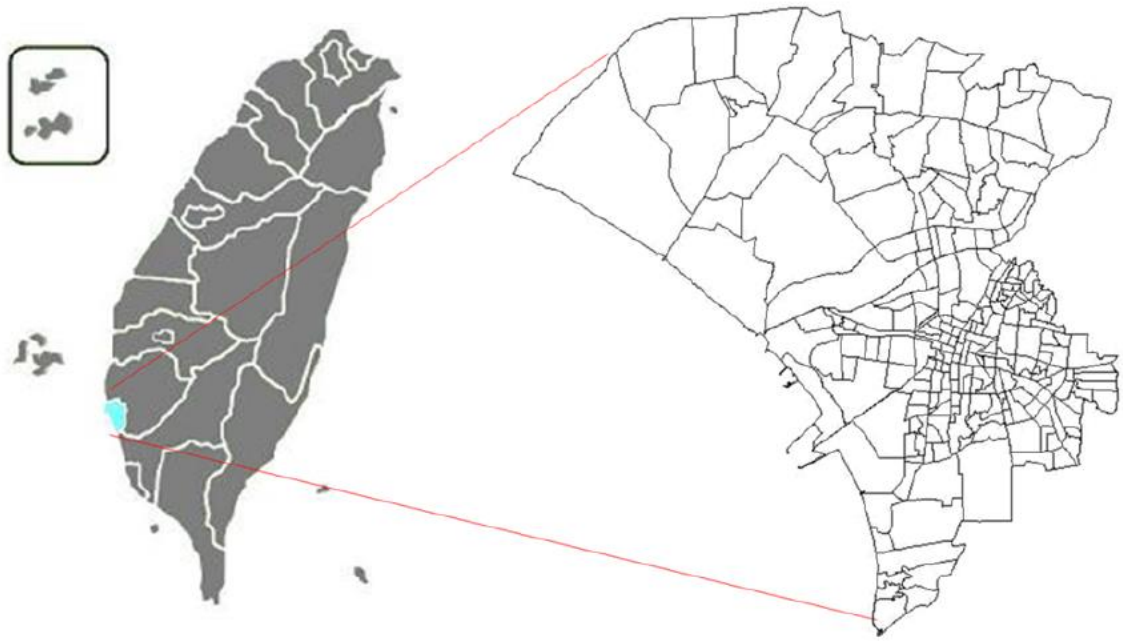

Figure 1: Study areas of Tainan city, Taiwan

2.2 The classification of LCZ

This study applied LCZ, a systematic classification scheme developed by Stewart and Oke (2012), to map land development patterns into climatological related zones. The scheme defines land development patterns according to the structural properties of buildings and vegetation, such as types, height, and density, as well as the types of land cover. Following the instruction on the World Urban Database and Access Portal Tools (WUDAPT), this study prepared the training areas of LCZs in Taipei Metropolis by Google Earth Pro (7.1.5.1557) and utilized SAGA GIS software (2.2.0) to perform classification. Given that LCZ8 and LCZ10 has similar characteristics in Tainan, this two LCZs were combined as LCZ10 for discussion. In total, sixteen LCZs were identified based on the Landsat 8 satellite image acquired on 16 November 2015.

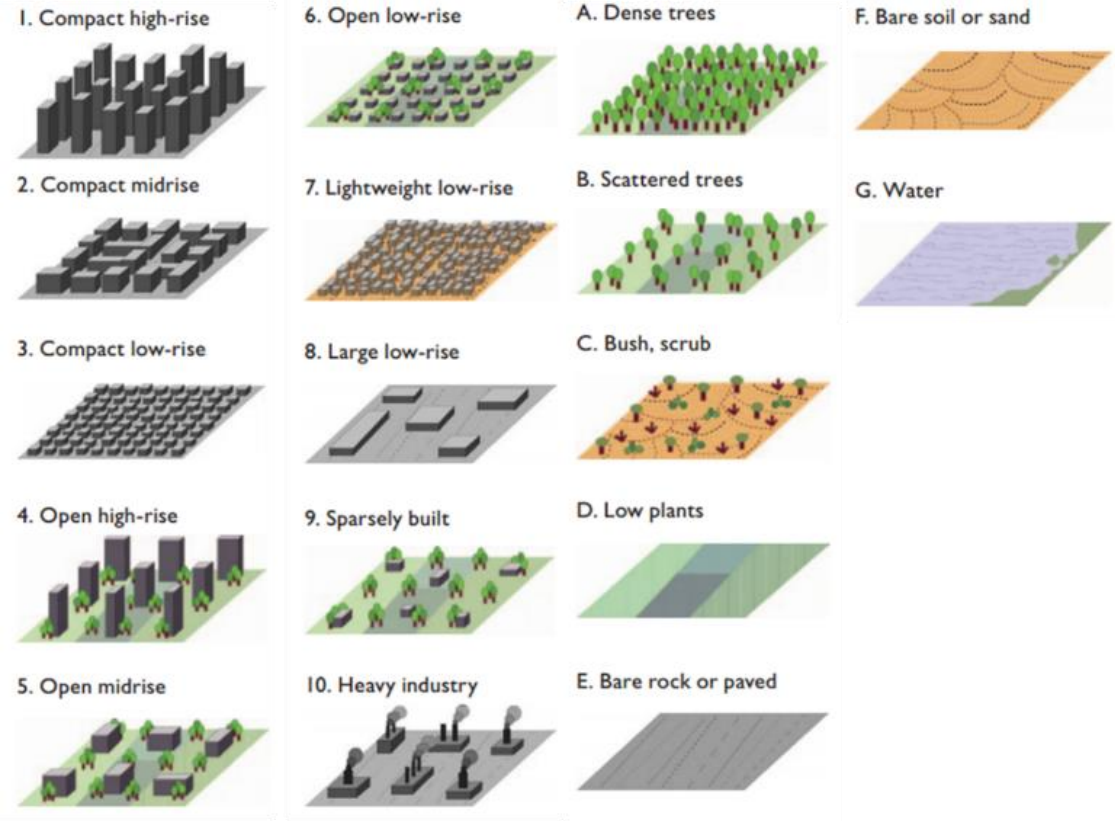

Figure 2: Local climate zone classification

2.3 Thermal conditions data

The thermal conditions data applied in the study is obtained from car traverse measurement on several thermal parameters in the previous project of Tainan cities, named "The development of urban thermal environment climatic map and hotspot analysis." The physiologically equivalent temperature (PET), which has been widely used to evaluate thermal comfort in outdoor spaces, based on the heat balance model of the human body (Höppe 1999; Matzarakis et al. 1999; Mayer and Höppe 1987; VDI 1998), are applied in this study for the evaluation of thermal condition in urban outdoors spaces at pedestrian level.

3. RESULT

3.1 The accuracy of LCZ classification by WUDAPT

Figure 3 shows the level 0 LCZ information in Tainan, it is obvious that the core area of Tainan is consisted of LCZ2 (Compact mid-rise) and LCZ3 (Compact low-rise), and the surrounding suburban areas are consisted of c repented as green area and water areas. In order to examine the accuracy of the LCZ generated by the WUDAPT approach and the land-use/ land-cover and building height in reality, the focus area has been selected and comparted, as show in Figure 4

In the focus area we choose the LCZ1 (Compact high-rise) area which is identified by the WUDAPT method and examine whether the height is correct compared the actual height by the building digital map. Finally, 33 grids (comprising 100m*100m for each grid) is selected for the analysis. Figure 5 shows the frequencies of actual building floors in the LCZ1 group classified by the WUDAPT in focus area in Tainan city. There are totally 2080 buildings in these LCZ1 areas.

In the definition of WUDAPT, it should be higher than 10 floor height. However, Figure 5 shows that more than 1445 building (approximate 70% of the total buildings) are lower than 7 floors, and the average height is 4.2 floors. It indicated that the WUDAPT may overestimate the building height compared to the actual height by the building digital map.

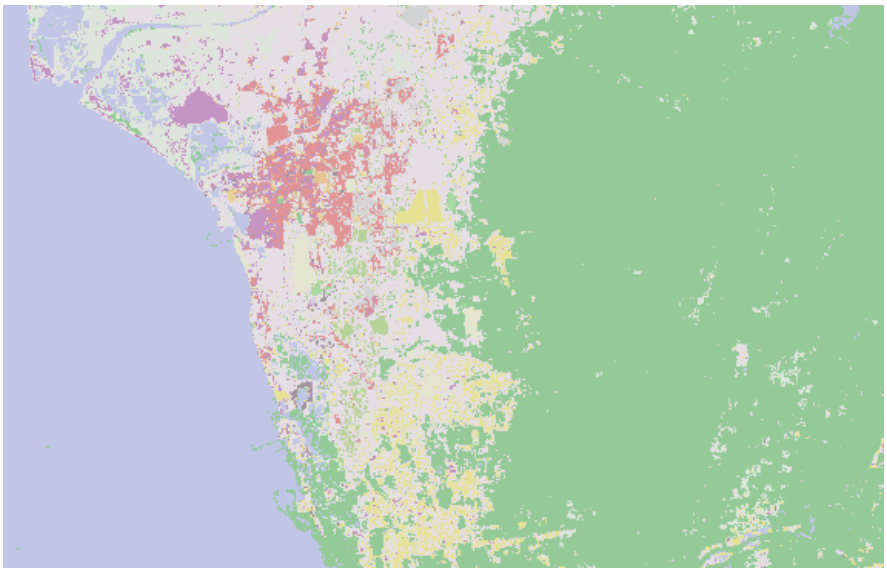

Figure 3: The LCZ map in Level 0 in Tainan city

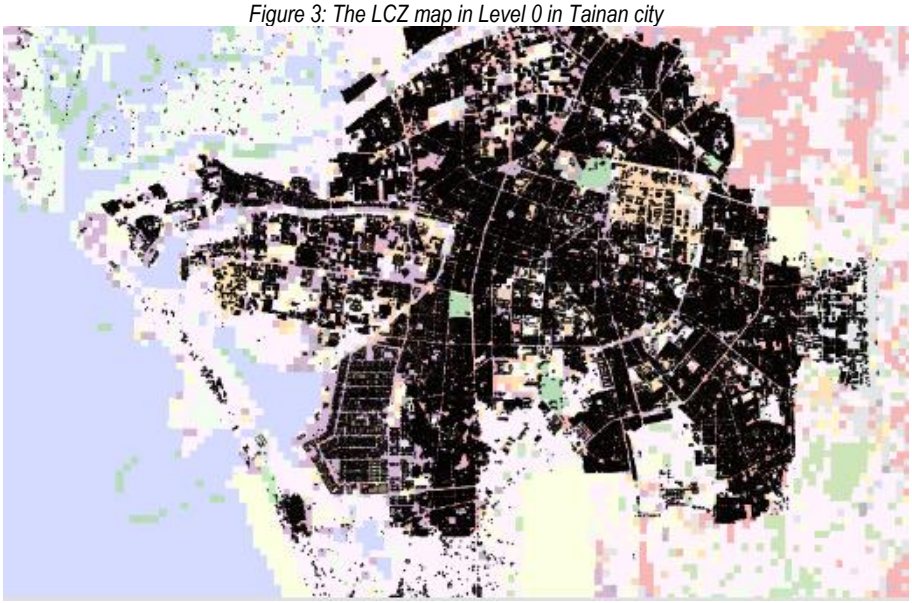

Figure 4: Focus area in Tainan city

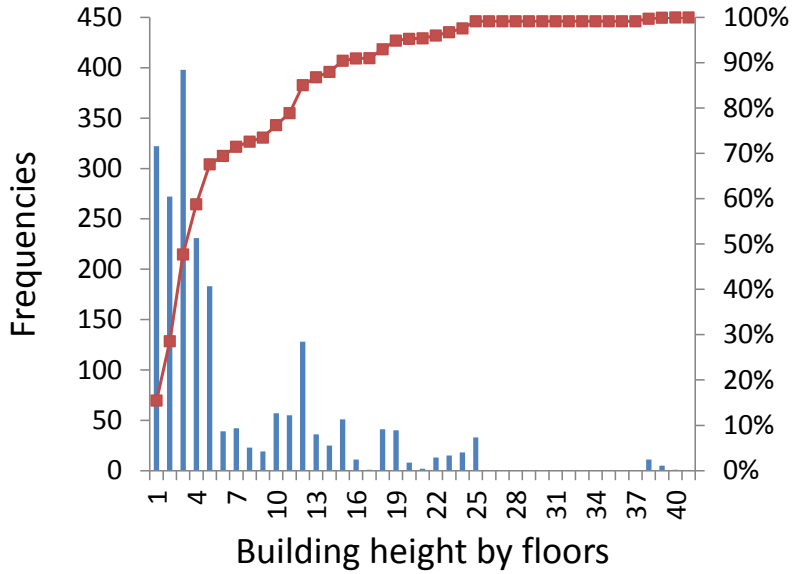

Figure 5: Frequencies of actual building floors in the LCZ1 group classified by the WUDAPT in focus area in Tainan city

3.2 The thermal conditions in various LCZ

Concerning the previous mentioned project on car traverse measurement, the PET of value of each LCZ is analyzed to examine whether the thermal conditions distributions will variate in different LCZs. Figure 6 shows the PET frequency distributions of four types of LCZ that are associated to different distinguishing feature, areas belong to LCZ2 (Compact mid-rise) and LCZ3 (Compact low-rise) have a higher thermal stress distribution, and areas belong to LCZ 6 (Open low-rise), LCZ 9 (Sparsely built) were contrary in low thermal stress. The kurtosis curves for LCZ6 and LCZ9 were higher than those for LCZ2 and LCZ3, revealing that the grids that were associated with LCZ6 and LCZ9 were more likely to have a low thermal load (34 – 35.5°C PET). The grids that were related to LCZ2 and LCZ3 were more likely to suffer from a high thermal load (> 35.5°C PET). Influenced by boundary effects, some grids, such as those associated with LCZ2 and LCZ3, had relatively low kurtosis curves, affecting the performance of nearby grids. The PET values of the LCZ2 and LCZ3 areas have higher variance, indicating that the grids that are associated with LCZ2 and LCZ3 will have a higher thermal load.

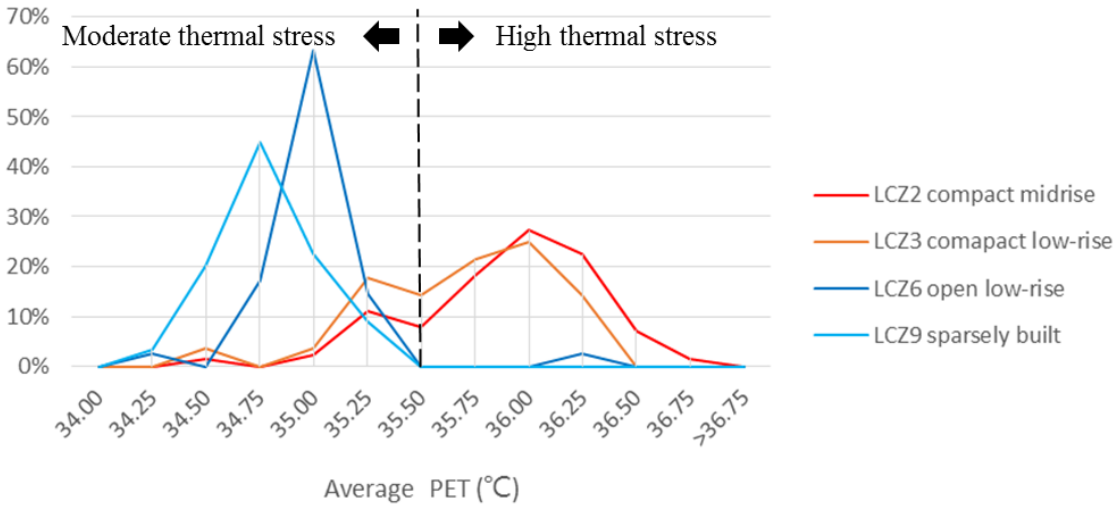

Figure 6: PET frequency distributions of four types of LCZ

4. CONCLUSIONS

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