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

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High density in urban area

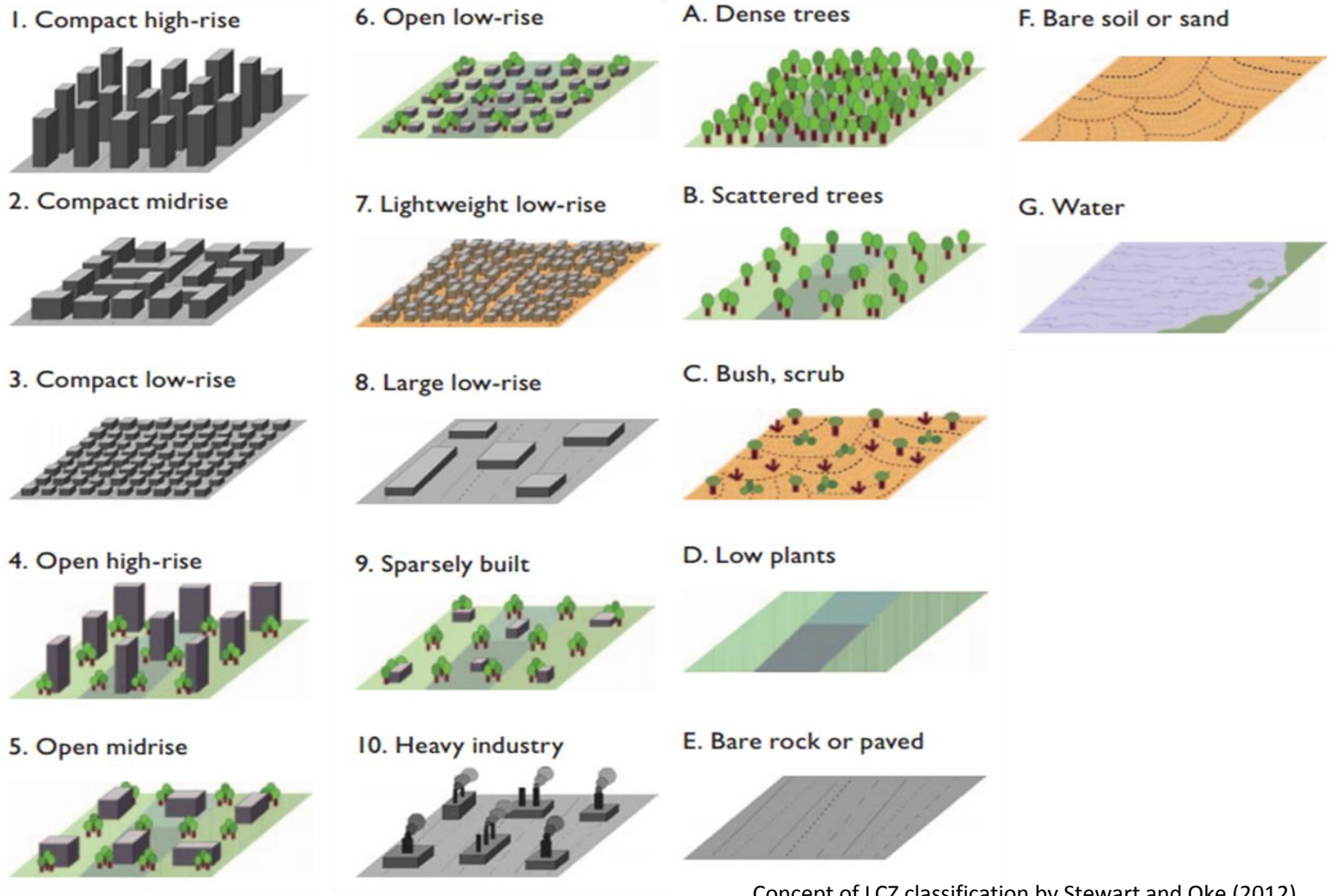
Air borne oblique terrestrial photograph power by Skyline Terra Builder PhotoMesh
Image from Jiann-Yeou Rau, Department of Geomatics, NCKU

Tainan is a historical city in Taiwan, with various built environment.

The thermal condition in the city is becoming more and more severe due to UHI caused by urbanization.

Mixed land use

Air borne oblique terrestrial photograph power by Skyline Terra Builder PhotoMesh
Image from Jiann-Yeou Rau, Department of Geomatics, NCKU



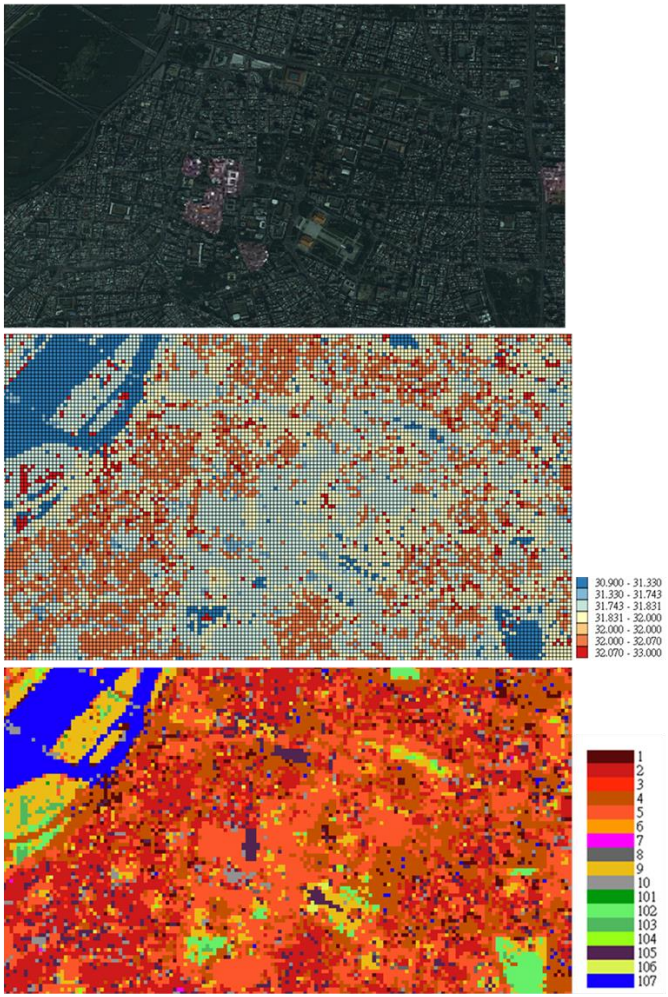
Concept of LCZ classification by Stewart and Oke (2012)

Local climate zone (LCZ) is a systematic classification scheme to map land development patterns into climatological related zones.

The scheme defines land development patterns according to the structural properties of buildings and vegetation and land cover type.

Main issue

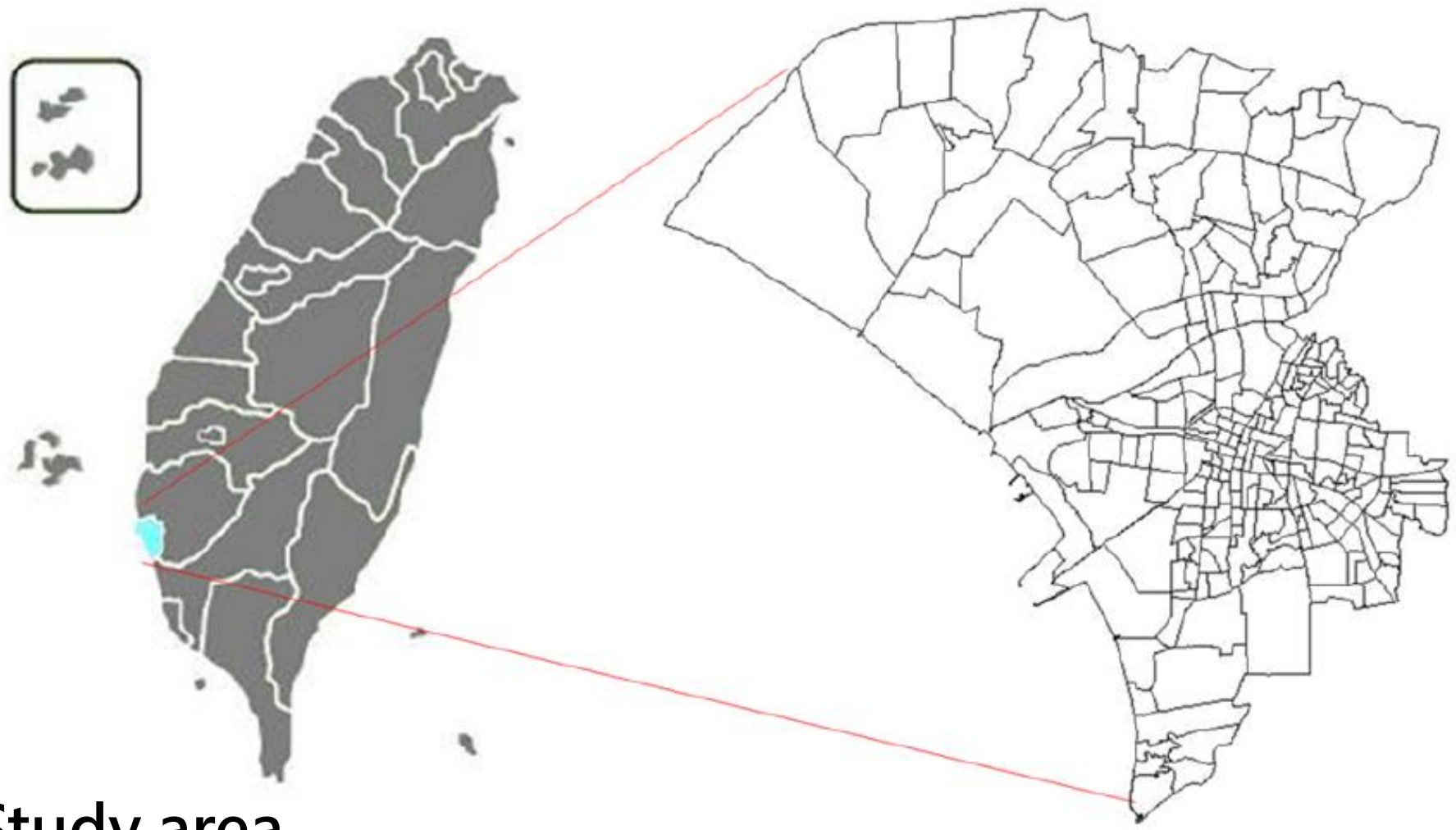
- Thermal environment in urban areas is highly related to urban morphology and building typology.
- Only the land use and land cover classification is not enough for evaluating the micro climate condition.
- The World Urban Database and Portal Tool (WUDAPT) can make a wild range LCZ distribution map in an efficient way.
- Complex urban built environment may have various different thermal condition.



Purpose

- To identify the LCZ and confirm if it is correct in reality.
- A method to quantify the thermal conditions in different LCZs.
- Contribute and benefit to the sustainable development in urban areas.

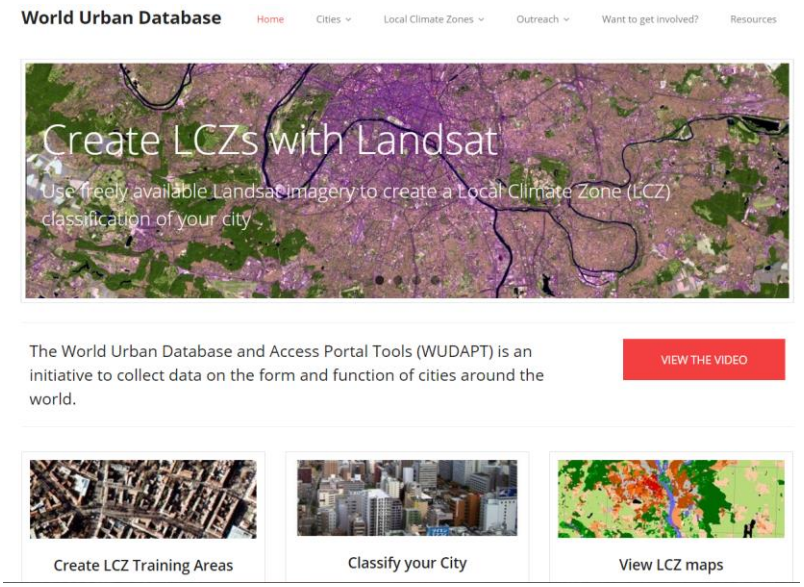
Method



Study area

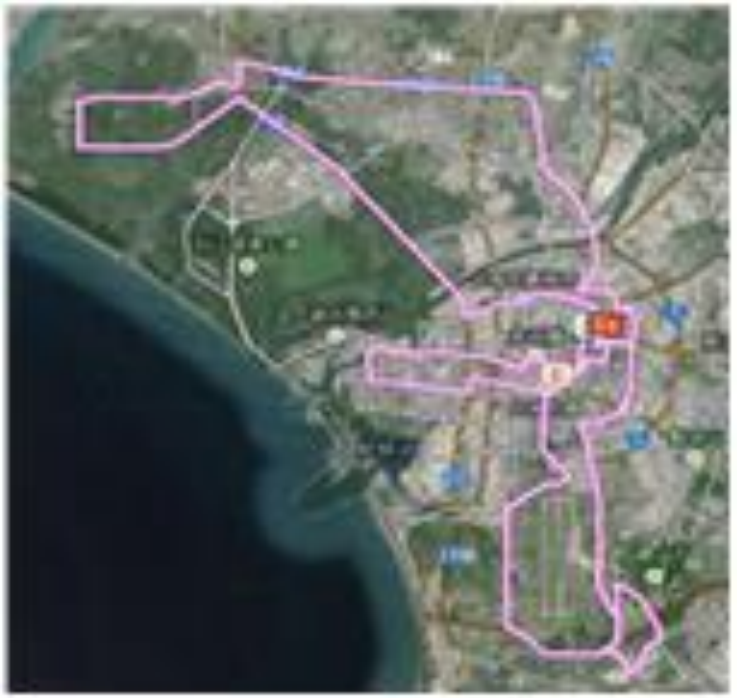
As a high development city in the south of Taiwan, Tainan is selected to be the study area.

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.



Remote sensing data process

- This study utilized the imagery of 29 July 2016 to classify LCZs.
- The Landsat image and google earth data are imported into the SAGA GIS to generate the LCZ distribution map in Tainan city, the resolution is 30m*30m.



Measurements data included air temperature, globe temperature, relative humidity and global solar radiation.

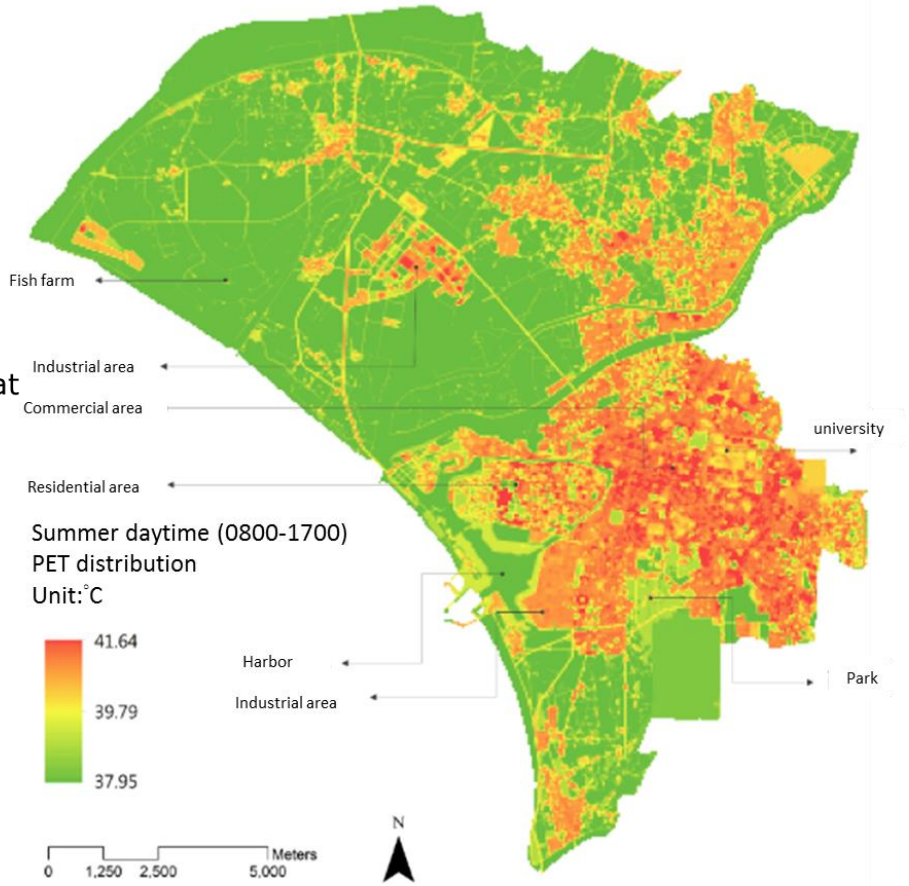
Thermal conditions data

- The thermal conditions data is obtained from car traverse measurement on several thermal parameters in the previous project of Tainan, named “The development of urban thermal environment climatic map and hotspot analysis.”

- $$PET_i = PET_{station} \times f\,(Development_i\,,\ Elevation_i)$$

- **PET_i** represents the prediction in each grid.
- **$PET_{station}$** represents the value of PET from the data measured at the fixed-point weather station.
- **$Development_i$** refer to urban development parameters in each grid including population, total floor area, ISA, NDVI and FAI.
- **$Elevation_i$** represents the mean elevation in each grid, and is used for correcting the result.

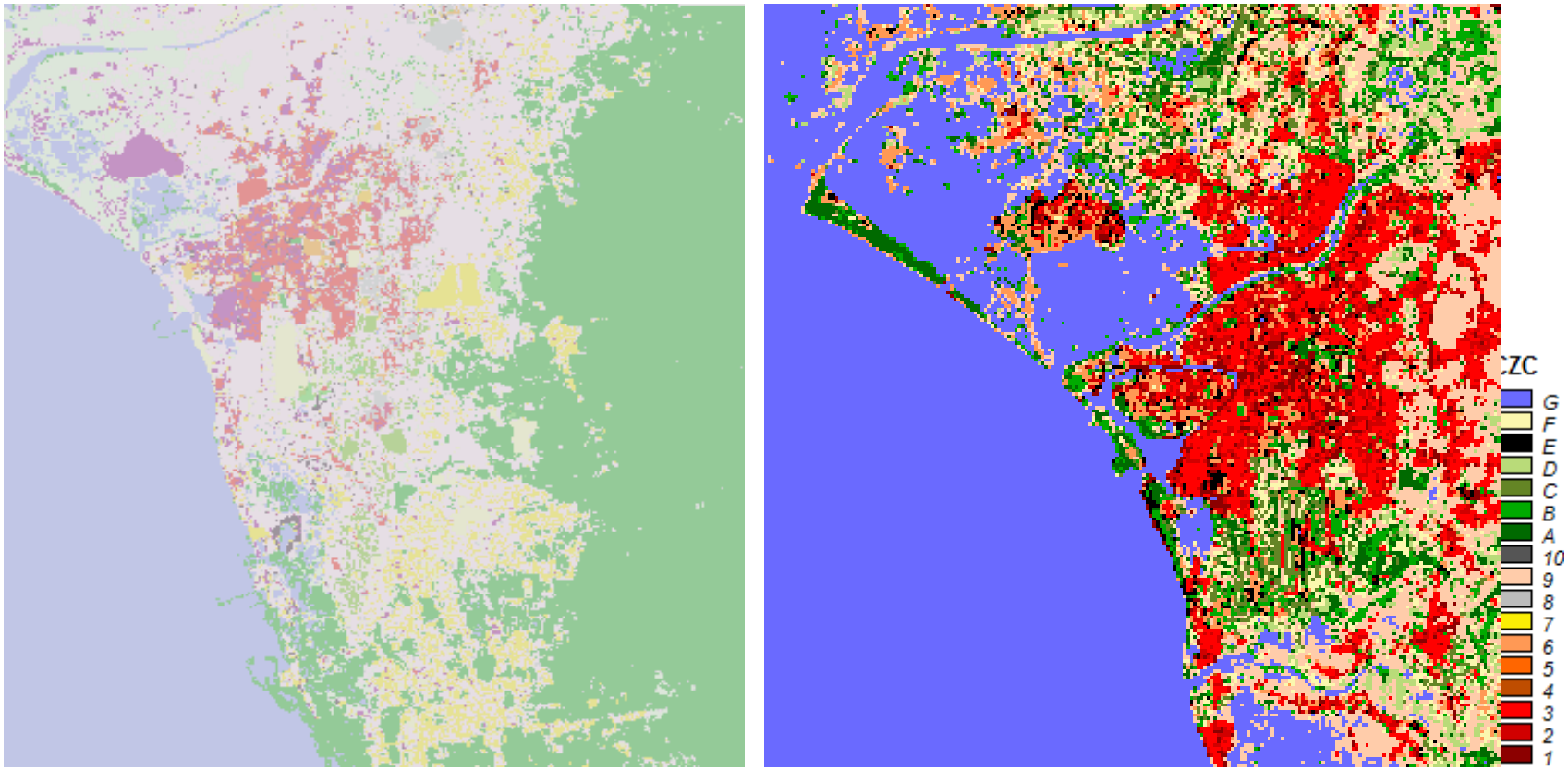
- $$Ta_i = Ta_{station} \times 0.42023 + \left(\frac{ISA_i}{ISA_{station}}\right) \times 0.51298 + \left(\frac{FAI_i}{FAI_{station}}\right) \times 0.40873 + 18.4215$$



Thermal condition index

- 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 are applied in this study for the evaluation of thermal condition in urban outdoors spaces at pedestrian level.

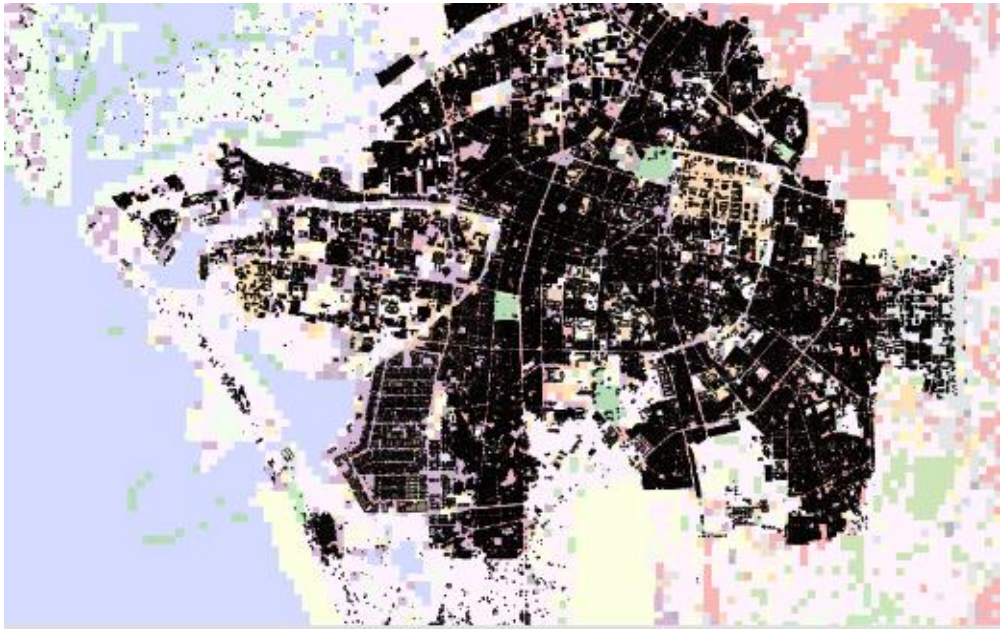
Results



The LCZ distribution map classification by WUDAPT

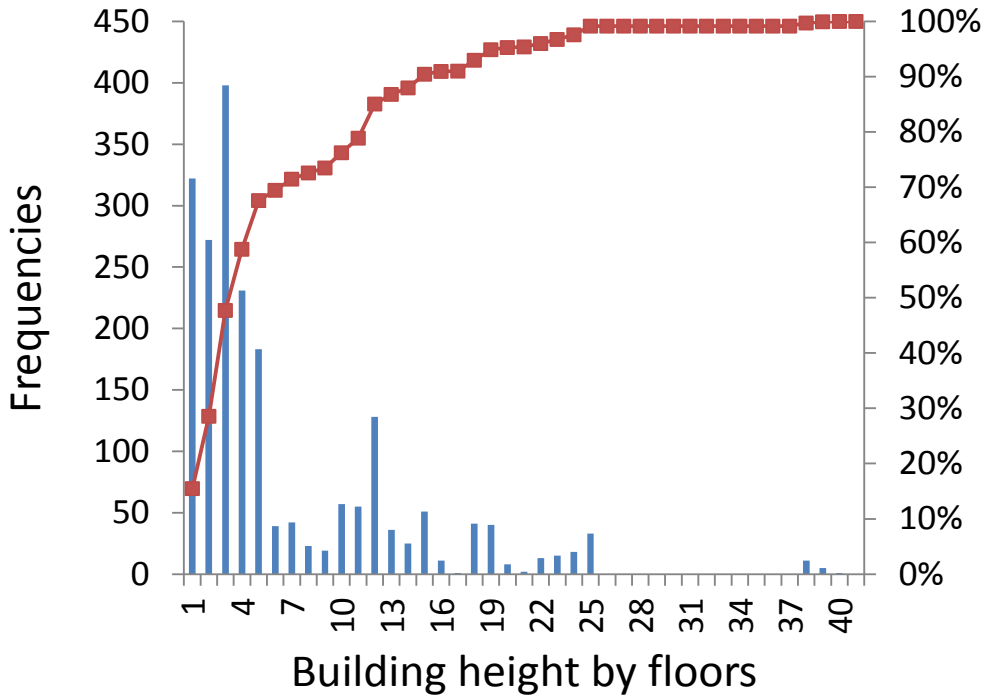
- The core area of Tainan is consisted of LCZ2 (Compact mid-rise) and LCZ3 (Compact low-rise), and the surrounding suburban areas are consisted of LCZAB&G repented as green area and water areas.

The accuracy of LCZ classification by WUDAPT

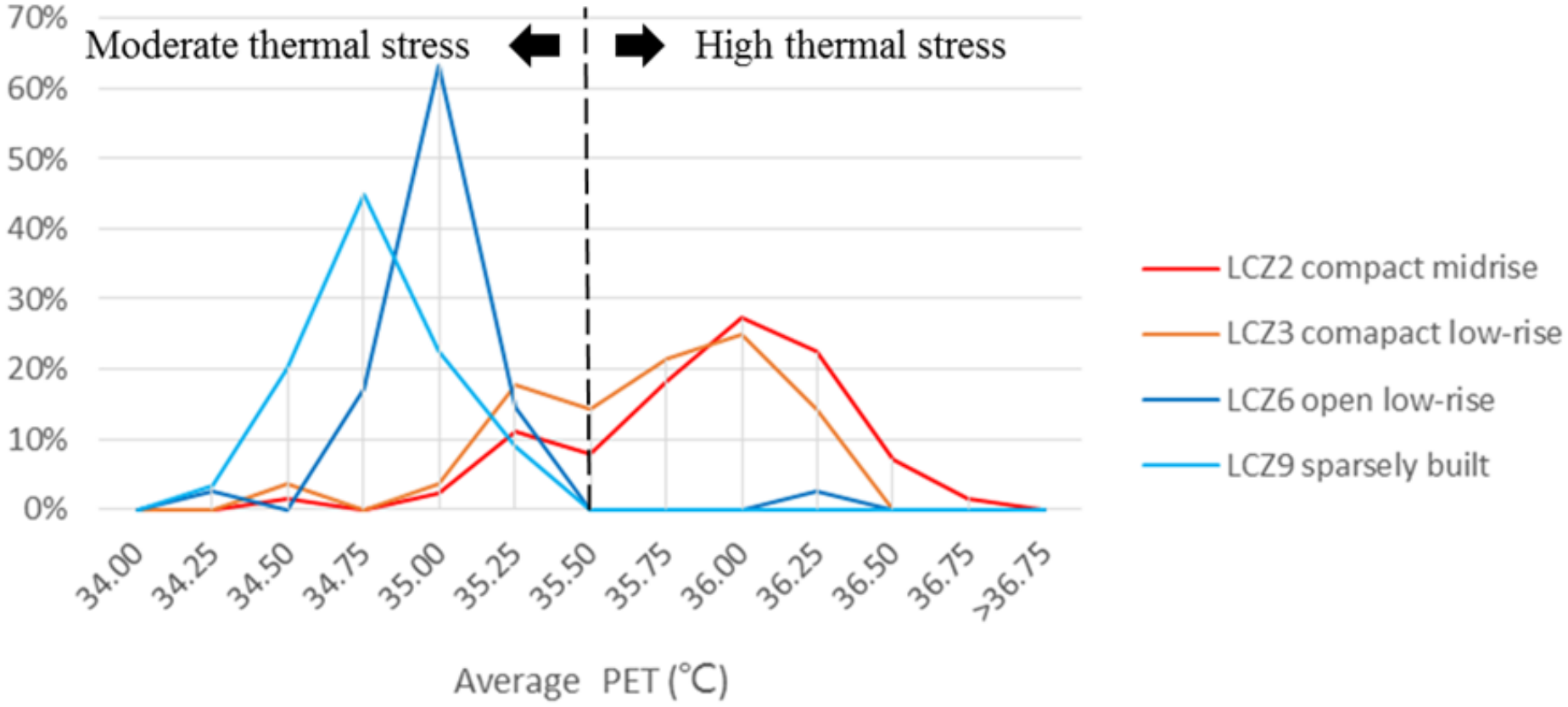


In order to examine the accuracy of the LCZ generated by the WUDAPT approach and the building height in reality, the focus area has been selected and comparted.

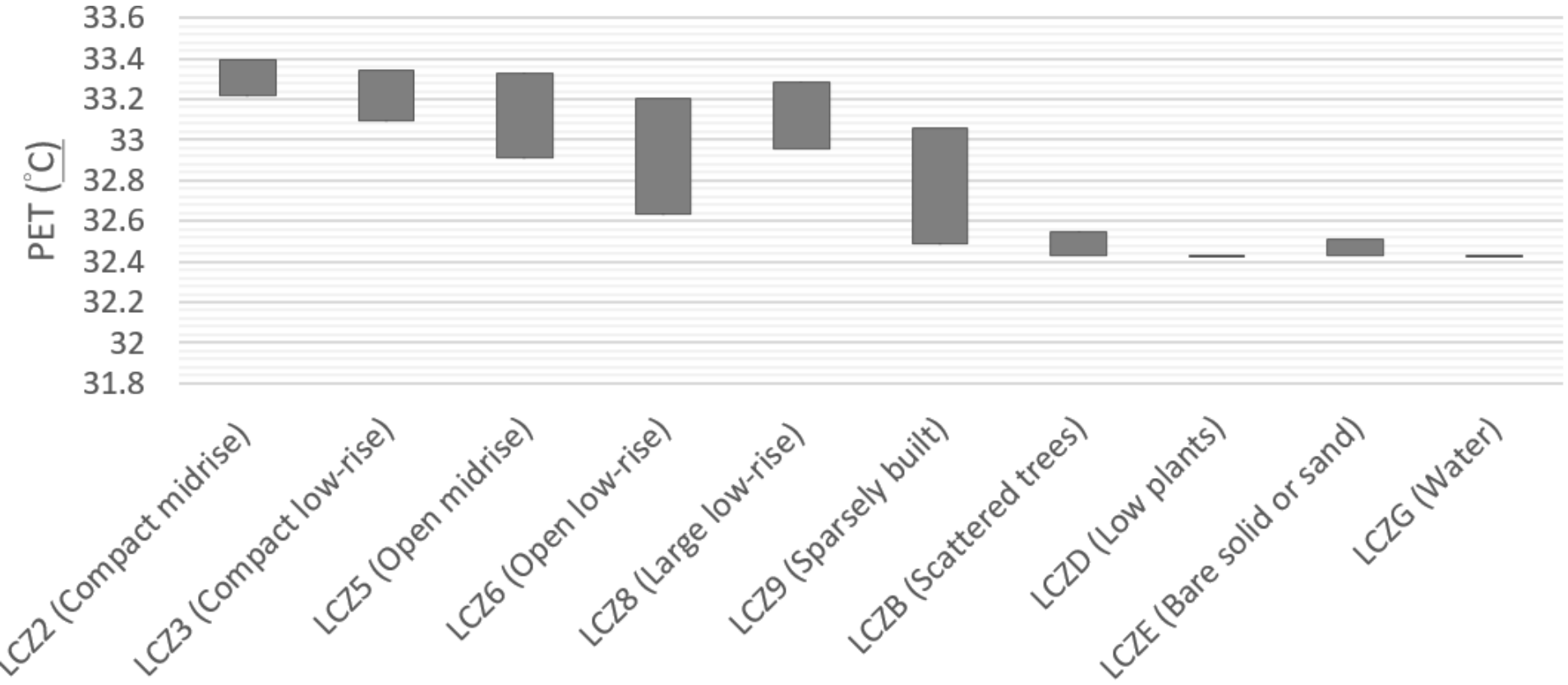
The result shows misclassify in building height, due to the LCZ3 should consist of only building with 1-3 floors, however, some building higher than 3 floor were also had been classified into this cataloged .

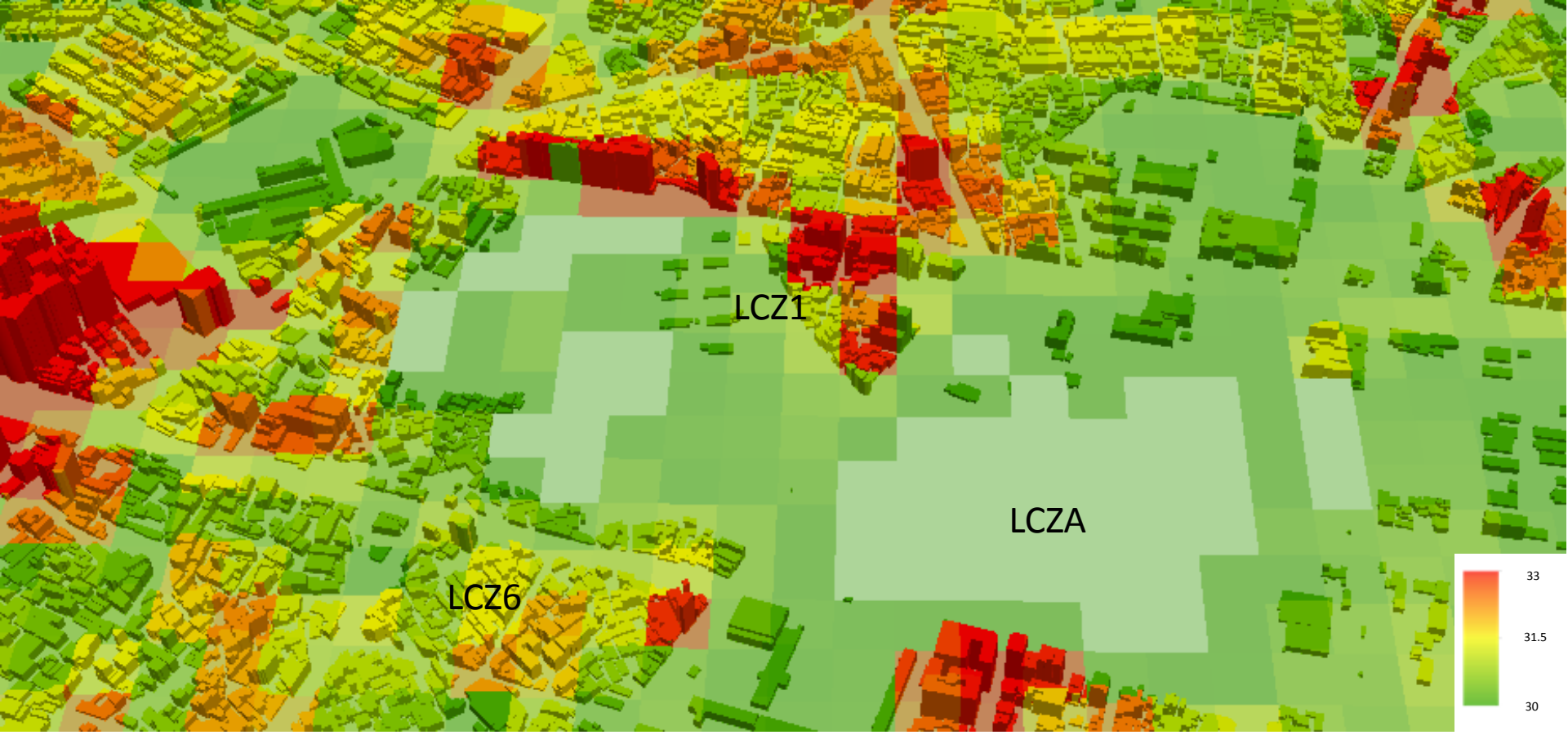


The thermal conditions in various LCZ



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.


33.6
33.4
33.2
33
32.8
32.6
32.4
32.2
32
31.8
PET (°C)
LCZ2 (Compact midrise)
LCZ3 (Compact low-rise)
LCZ5 (Open midrise)
LCZ6 (Open low-rise)
LCZ8 (Large low-rise)
LCZ9 (Sparsely built)
LCZB (Scattered trees)
LCZD (Low plants)
LCZE (Bare solid or sand)
LCZG (Water)



Visualization map

Therefore, Tainan is presented as a high development density city and easy to form a high thermal load condition owing to the high energy consumption and the ventilations cannot pass by directly to take away the storage heat in the area that are surrounded by compact high buildings.

Conclusion

- The WUDAPT may misestimate 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 areas.

- The grids that were associated with LCZ6 and LCZ9 were more likely to have a low thermal load (34 – 35°C PET). The grids that were related to LCZ2 and LCZ3 were more likely to suffer from a high thermal load (> 35°C PET).

- This study suggests that areas belong to LCZ2 and LCZ3 in specific area of Tainan should be restricting to minimize the risk of the increasing thermal load and reduction of ventilation, in order to achieve the sustainability of built environment in the future.

Thanks for your attention