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URBAN HEAT HAZARD THREAT ON UNIVERSITY CAMPUS (University of Indonesia and University of Malaya)

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ABSTRACT: Urban landcover reflects the sun heat called urban heat signature. The urban university campus, as part of an urban environment, had a potential urban heat hazard. These urban heat hazards related to the highest temperature when above the threshold will become a hazard. The research aims to assessments of urban heat hazard thread on universities campus. The study area chose the University of Malaya (UM) and the University of Indonesia (UI) Campuses, which tropical area. This research used spatial-temporal analysis employing satellite images during the period 2013-2016, Field Measurement of Air Surface Temperature in 2015, and Perception Study of Heat Hazard 2017-2018. The study found an urban heat signature maximum is 33-36ºC and a trend of UHS since 2013-2016 with temperature >32ºC both UM and UI campuses. Urban heat hazard overlaid from urban heat signatures, air surface temperature, and perception of heat on landcover types. The study concludes that increased temperature above the threshold is causing by land cover change on tropical university campuses. The temperature of Urban Heat Signature, Air Surface Temperature, and Perception Study of Heat concludes that a combination of three aspects (overlaid) generated an Urban Heat Hazard on tropical university campuses. Both UM and UI campuses had a distribution a very high of urban heat hazards related to paved open space and building covered. The study concludes that urban heat hazard threat is causing by temperature above a threshold based on landcover types on tropical university campuses.

Keywords: Land cover, Urban heat hazard, threat, spatial analysis

1. INTRODUCTION

Land use and land cover are two interchangeable terminologies, where land cover described as the physical characteristic of the earth's surface, and land use as a character is using by humans [1]. Urban and suburban areas have long observed to have a reverse area where air and surface temperature was hotter than in their rural surroundings [2]**.** The urban area is a landscape with different land cover types and human activities due to population and activities enabling better urban living [3]. Urbanization is one of the major transformations affecting the natural environment, and in particular, it has aggravated a tension on the environment components at the scale of landscapes, and directly impact the ecosystem processes [4]**.**

Urban heat is a phenomenon caused by the relationship between solar heat and land cover [5]. Urban heat is a consequence of urban setting or urban growth [6]. The urban heat effect resulted in an observed maximum temperature difference of 4.01°C between a well-planted area and the central business district area [7], with an air temperature minimum of 26°C and a mean temperature of 30°C [8]. The urban heat intensity varies between highly developed and lowly developed areas or between areas with different build-up areas [9]. These negative impacts could degrade the environment's quality and cause many problems in a tropical environment [10].

Furthermore, combining the effects of anthropogenic heating in city centres with other factors, such as low vegetation cover and dark surfaces, can enhance the heat effect [11]. The heat effect on an urban area called urban heat signature. Urban Heat Signature (UHS) to explain Land Surface Temperature (LST) reflected from different land-cover types [12]. Whenever urban heat signatures above their threshold, it will become an urban heat hazard threat [13]. The urban heat hazard could be a threat to sustainable urban environmental quality and human well-being.

Sustainable university action is implemented on the main campus to promote environmental development and transform it into a "green campus" [14]. The internal environment of a university campus reflects an essential measure in favour of sustainable development [15]. Since 2010, the university community lead by UI created the UI Green Metrics World University Ranking (greenmetric.ui.ac.id). That is a real concern for the university community around the world to the sustainability of good quality of life [16].

Land cover types in urban universities similar to urban areas [17]. As an institution, a university has a responsibility to the community to support better urban living [18,19] and conduct research addressing better urban life on its campus. However, the study of urban land cover types, urban heat signatures, and urban heat hazard threats in the university are limited. That is the objective study of urban heat hazards in the university campus area. To understand urban heat hazards, which has monitoring land cover, is required [20]. The study using urban heat signatures, air surface temperature, and perception study to give a new understanding of land cover changed to ensure sustainable environmental quality and human well-being on university campuses.

2. METHOD

The land cover, urban heat signature, air surface temperature, and perception study used to answer the research objective. This research used Google Earth data archive to generated land cover types [21] between 2013 and 2018 on both universities. Thermal satellites by Landsat 8 TIRS from USGS to makes LST and generated to UHS. The Landsat satellites provide the longest temporal record of space-based land surface observations [22]. The urban heat hazard identified via data-gathering methods [3,23], from a thermal band of Landsat 8 to acquire land surface temperature [17,24]. To generate the UHS [5]. The Landsat data for the UM campus used path 127 and row 058, path 122, and row 064 for the University of Indonesia, acquired from 2013 to 2016.

Air Surface Temperature collect used surveys by the rapid 10-15 minute in daylight in June 2013, October 2014, and March 2015. The air temperatures measured each value saved on a picture (smartphone or camera) then stored manually in the database acquired used mobile temperature and humidity tool [25]. Field visits were conducted in 2013-2015 in the two universities, with data collecting by 10 hours. Sampling data for air surface temp based on land cover, e.g., building covered, paved open space, water bodies, open vegetated, and dense vegetated covered.

The perceptions of respondents investigated to identify the level and type of impact of the natural hazard [26]. The perception of student university about their environment assessed and evaluated using data collected with a questionnaire distributed to 100 students on UM and UI Campuses. The student respondents from universities using an online survey, the respondents answered questions about their perception of heat and land cover types, and the potential impact of urban heat hazard on human activity.

The threshold of becomes a hazard whenever the temperature of land cover types is above 32°C with category strong heat stress [3]**.** The threshold based on the Universal Temperature Climate Index [3] for assessing the Urban Heat Hazard (UHH). The UHH using spatial analysis (spatial pattern) and overlay between landcover types, UHS, Air Surface temperature, and perception study within a Likert scale from 1 until 5. The scale/index 1-5, which 1 is a very low hazard, 2 is a low hazard, 3 is a moderate hazard, 4 is the highest hazard, and 5 is a very high hazard. The rest of the results were related to landscape features and their urban heat hazard threats at urban universities. Thus, all geodatabase storage and process into a summary and layout set within a standard symbol, colour, and layout used ArcGIS with a cartographic standard.

3. RESULT AND DISCUSSION

3.1 Urban Heat Hazard on UM Campus

The UM campus, an urban campus, had total percentage areas of these features for greenery area with 64.3% and non-greenery areas of 35.7% in 2013, and greenery area with 61.4% and non-greenery area 38.6% in 2018 (Fig.1). The UM campus was 20.1% covered by building cover and 56.3% covered by the densely vegetated surface in 2013. On the other hand, the UM campus was campus 22.4% covered by building cover and 53.4% covered by the densely vegetated surface in 2018. The lowest densely vegetated covered in 2018 compared to 2013, a 6.0% change of land cover types in the UM campus. The rest of the land cover types presented in Table 1.

Table 1 The land cover in UM Campus 2013-2018

Land cover Types	2013 Area (ha)	2013 (%)	2018 Area (ha)	2018 (%)
Paved Open	52.9	20.1	54.1	22.4
Building	67.3	15.8	75.2	16.1
Open Vegetated	23.3	6.9	23.7	7.1
Dense Vegetated	189.0	56.3	179.0	53.4
Water Bodies	3.0	0.9	3.0	7.1

Source: data process and analysis

Table 2 explained the relationship between land cover types and Urban Heat Signature (UHS). The UM Campus had UHS 2013, max temp for all land cover types is 31.0°C except water bodies with min temp 30.0°C. Based on UHS 2014 max temp on Paved Open Space and Building Covered are 39.0°C, the rest of the lowest than temp 37.0°C and Dense vegetated had temp. 34.0°C.

Based on UHS 2015 max temp on Paved Open Space, Building Covered and Dense Vegetated Covered with temp 33.0°C, the Open Vegetated Cover and Waterbodies had max temp lowest than

33.0ºC. Based on UHS 2016 max temp on Paved Open Space and Building Covered with temp 36.0ºC, and Dense Vegetated Cover had max temp 34.0ºC (Fig.2).

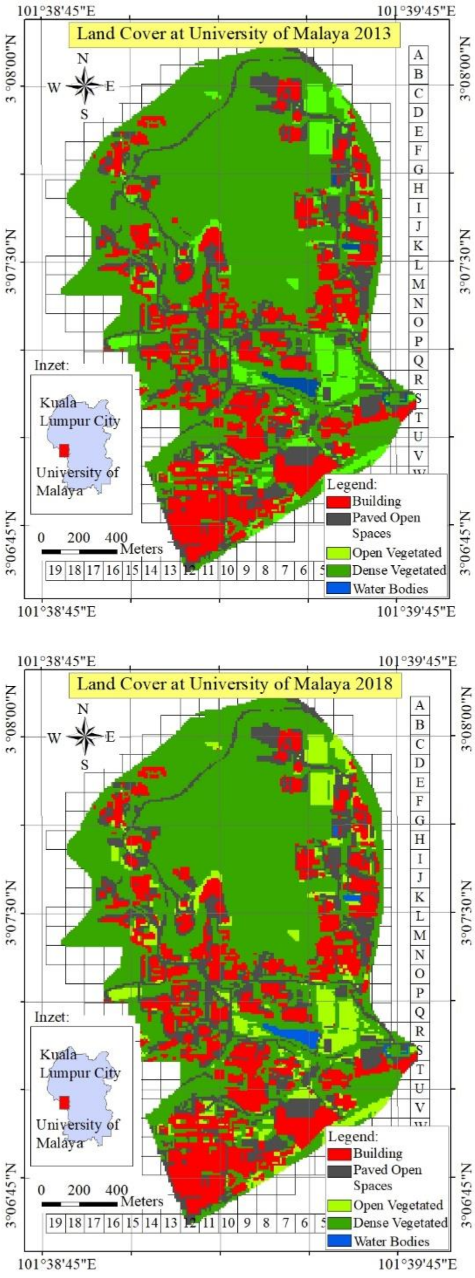

Fig.1 Land Cover 2013 and 2018 on UM Campus.

Table 2 The land cover and Maximum UHS in UM Campus 2013-2016

Land cover types	2013 (ºC)	2014 (ºC)	2015 (ºC)	2016 (ºC)
Paved Open	31.0	39.0	33.0	36.0
Building	31.0	39.0	33.0	36.0
Open Vegetated	31.0	37.0	32.0	35.0
Dense Vegetated	31.0	34.0	33.0	34.0
Water Bodies	30.0	36.0	31.0	35.0

Sources: data processing and analysis

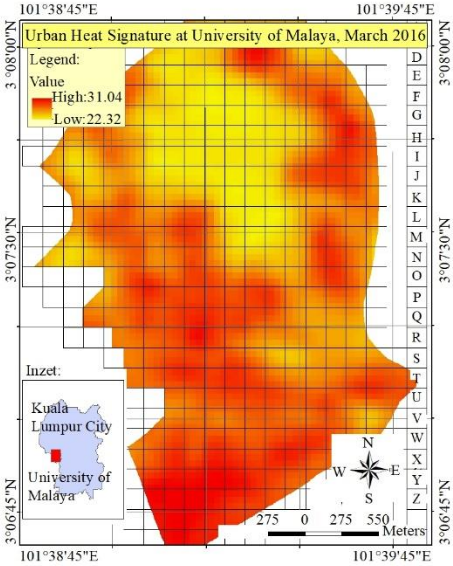

Fig.2 Urban Heat Signature March 2016 at Univ Malaya Campus.

Table 3 The UHS in UM Campus 2013-2016

Land cover types	2013 (ºC)	2014 (ºC)	2015 (ºC)	2016 (ºC)	UHS Index
Paved Open	31.0	39.0	33.0	36.0	5
Building	31.0	39.0	33.0	36.0	4
Open Vegetated	31.0	37.0	32.0	35.0	3
Dense Vegetated	31.0	34.0	33.0	34.0	1
Water Bodies	30.0	36.0	31.0	35.0	2

Sources: data processing and analysis

Analysis Impact on Human used data from UHS Behavior at UM Campus from 2013-2016 then create an index of UHS Behavior base on Land cover types showed in Table 3. The index 1-5, which 1 is a very low hazard, 2 is a low hazard, 3 is a moderate hazard, 4 is the highest hazard, and 5 is a very high hazard. Paved open space is UHS with five or very high hazard.

Table 4 The Air Surface Temperature in UM Campus 2014 and 2015

Land cover types	2013 (ºC)	2015 (ºC)	AST Index
Paved Open	34.4	34.3	5
Building	34.5	34.8	4
Open Vegetated	34.4	33.2	3
Dense Vegetated	34.1	35.2	1
Water Bodies	33.9	34.1	2

Sources: data processing and analysis

UHS affects the environment, which caused the air surface temperature to get hot. The research asses the air surface temperature, using UTCI based on land cover types create the index showed in Table 4. Paved open space is AST with five or very high hazard.

Based on respondents from the perception of heat intensity study at UM campuses, the respondent was answering the hot perception (5) was paved open spaces. Moreover, dense vegetation covered as a neutral perception (1) (Table 5).

Table 5 The Temperature Perception Study Index in UM Campus in 2018

Land cover types	Min (ºC)	Max (ºC)	PS Index
Paved Open	28.0	>34.0	5
Building	28.0	34.0	4
Open Vegetated	28.0	30.0	3
Dense Vegetated	28.0	30.0	1
Water Bodies	30.0	32.0	2

Sources: data processing and analysis

Table 6 The Urban Het Hazard Index in UM

Land cover types	UHS	AST	PS	UHH
Paved Open	5	5	5	5
Building	4	4	4	4
Open Vegetated	3	3	3	3
Dense Vegetated	1	1	1	1
Water Bodies	2	2	2	2

Sources: data processing and analysis

The temperature based on Urban Heat Signature, Air Surface Temperature and Perception Study generated Urban Heat Hazard Index saw in Table 6 and created the Urban Heat Hazard Map shown in Fig. 3. The index 1-5, which 1 is a very low hazard, 2 is a low hazard, 3 is a moderate hazard, 4 is a high hazard, and 5 is a very high hazard. Paved open space is a very high hazard. The southern part was clustering the highest heat hazard.

3.2 Urban Heat Hazard on UI Campus

The UI campus had a total percentage of areas of greenery area with 77.7% and non-greenery area of 22.3% in 2013, and the greenery area with 74.1% and non-greenery area of 25.9% in 2018 (Fig.4). The UI campus was 10.0% covered by building cover and 64.0% covered by the densely vegetated surface in 2013. On the other hand, 13.1% covered by building cover and 59.7% covered by the densely vegetated surface in 2018. There is a percentage lower of densely vegetated covered in 2018 than 2013, which was 8.8% change of land cover types in UI campus. The rest of the land cover types of feature percentages presented in Table 7.

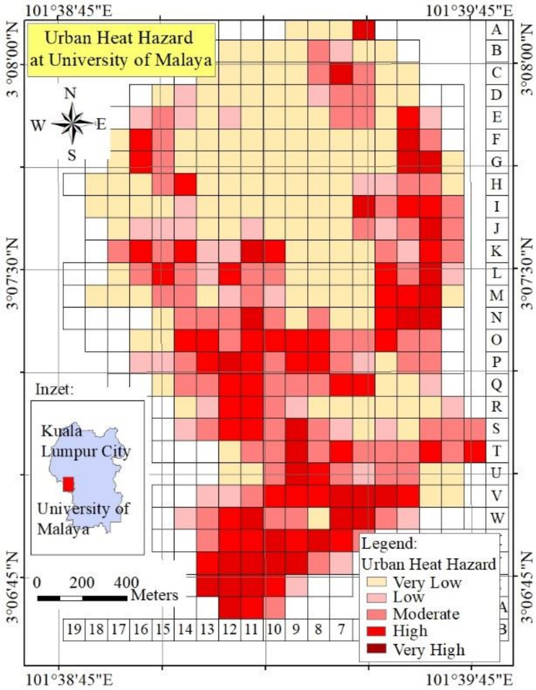

Fig.3 Urban Heat Hazard on UM Campus

Table 7 The land cover in UI Campus 2013-2018

Land cover Types	2013		2018	
	Area (ha)	(%)	Area (ha)	(%)
Paved Open	35.8	11.6	39.3	12.7
Building	33.0	10.7	40.5	13.1
Open Vegetated	19.3	6.3	22.0	7.1
Dense Vegetated	197.4	64.0	184.2	59.7
Water Bodies	22.9	7.4	22.4	7.3

Source: data process and analysis

Table 8 explained the relationship between land cover types and UHS in the UI Campus. Based on Table 8, the UI campus had UHS 2013 max temp for all land cover types is 31.0ºC except water bodies with min temp 30.0ºC. Based on UHS 2014 max temp on Paved Open Space and Building Covered are 39.0ºC, the rest of the lowest than temp 37.0ºC and Dense vegetated had temp. 34.0ºC. Based on UHS 2015 max temp on Paved Open Space, Building Covered and Dense Vegetated Covered with temp 33.0ºC, the Open Vegetated Cover and Waterbodies had max temp lowest than 33.0ºC (Fig. 5). Based on UHS 2016 max temp on Paved Open Space and Building Covered with temp 36.0ºC, and Dense Vegetated Cover had max temp 34.0ºC.

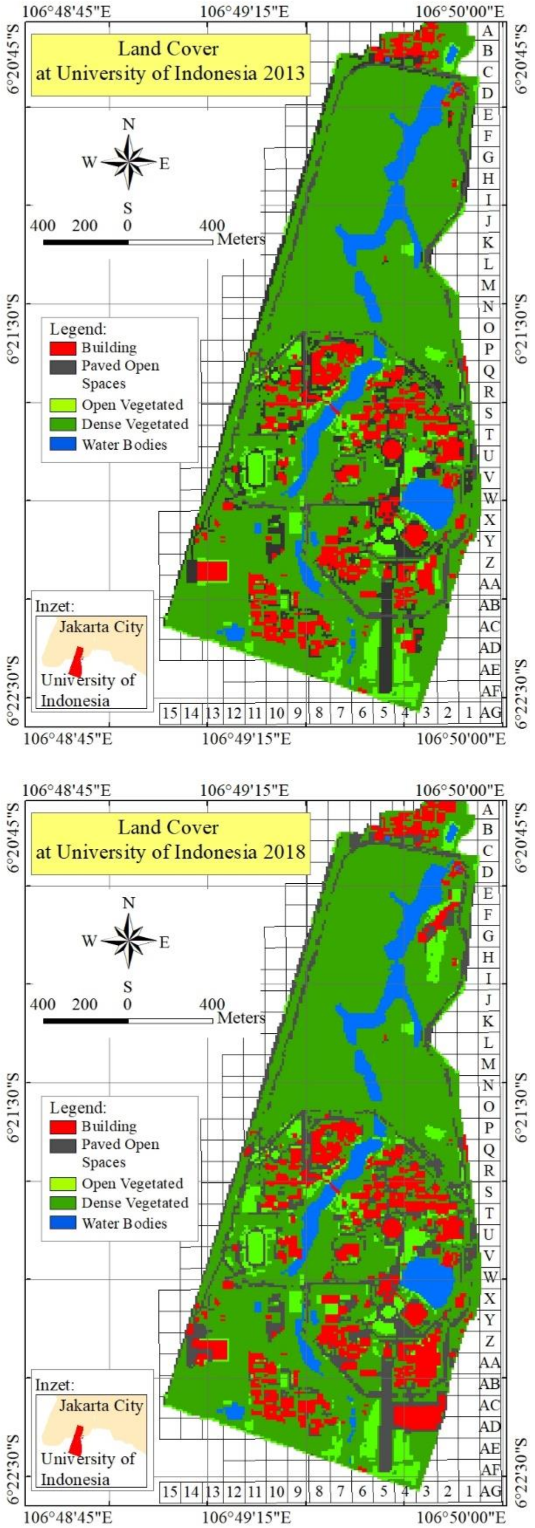

Fig.4 Land Cover 2013 and 2018 on UI Campus.

To analyze the impact on human used data from UHS behaviour from 2013-2016, create an index of UHS Behavior base on Land cover types at UI Campus shown in Table 9. Dense vegetated covered is a UHS with one or very low hazard.

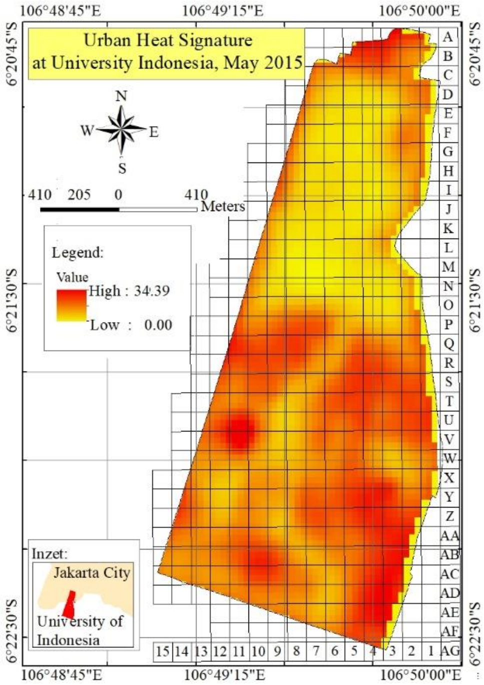

Fig.5 Urban Heat Signature May 2015 at the University of Indonesia Campus.

Table 8 The land cover and Maximum UHS in UI Campus 2013-2016

Land cover types	2013 (ºC)	2014 (ºC)	2015 (ºC)	2016 (ºC)
Paved Open	35.0	34.0	33.0	34.0
Building	33.0	33.0	31.0	33.0
Open Vegetated	35.0	35.0	33.0	35.0
Dense Vegetated	34.0	33.0	32.0	33.0
Water Bodies	32.0	31.0	30.0	31.0

Sources: data processing and analysis

The research also uses the air surface temperature index based on Land cover types. UHS will affect the environment, which caused the air surface temperature to get hot. The result of AST and land cover types showed in Table 10. Same as the UHS, in the AST of land cover type, is densely vegetated covered is a UHS with index one (1) or very low hazard.

Table 9 The land cover and maximum UHS in UI Campus 2013-2016

Land cover types	2013 (ºC)	2014 (ºC)	2015 (ºC)	2016 (ºC)	UHS Index
Paved Open	35.0	34.0	33.0	34.0	5
Building	33.0	33.0	31.0	33.0	4
Open Vegetated	35.0	35.0	33.0	35.0	3
Dense Vegetated	34.0	33.0	32.0	33.0	2
Water Bodies	32.0	31.0	30.0	31.0	1

Sources: data processing and analysis

Table 10 The Air Surface Temperature on Land Cover in UI Campus 2014-2015

Land cover types	2013 (ºC)	2015 (ºC)	AST Index
Paved Open	35.6	33.9	5
Building	36.7	34.1	4
Open Vegetated	38.4	33.3	2
Dense Vegetated	37.7	33.1	1
Water Bodies	39.0	33.3	3

Sources: data processing and analysis

Based on respondents from the perception of heat intensity study at UI, the respondent had a perception that paved open space as a hot area or highest temperature (5). Furthermore, dense vegetation covered as a neutral perception (1). (Table 11).

Table 11 The Temperature Perception Index in UM Campus 2016-2017

Land cover types	Min (ºC)	Max (ºC)	IPS Index
Paved Open	28.05	>34.0	5
Building	28.0	34.0	4
Open Vegetated	28.0	30.0	3
Dense Vegetated	28.0	30.0	1
Water Bodies	30.0	32.0	2

Sources: data processing and analysis

Based on Perception Intensity Study at UI Campus, almost respondents answer that is Paved Open Space as an area with hot perception and Dense Vegetation Covered as an area with neutral perception. Those based on Urban Heat Signature, Air Surface Temperature and Perception Intensity Study generated Urban Heat Hazard Index showed in Table 12 and created the Urban Heat Hazard Map shown in Figure 6. The Moderate and High Hazard clustering in the southern part of UI Campus.

Table 12 The Urban Het Hazard Index in UI

Land cover types	UHS	AST	IPS	UHH
Paved Open	5	5	5	5
Building	4	4	4	4
Open Vegetated	3	3	3	3
Dense Vegetated	1	1	1	1
Water Bodies	2	2	2	2

Sources: data processing and analysis

The result of both campuses had similar value or index (1-5) with 5 is the highest heat. Both campuses concluded value or index of land cover change effect on urban heat signature become a hazard.

Trees in urban areas are essential for the residents in summer as they can improve the urban climatic condition through shading and transpiration, whereas plants release water vapour into the surroundings, increasing relative humidity and decreasing air temperature [27]. The temperature of the narrow green alleys is lower than that of their counterparts. The research had similar results compare to Ali and Patnaik, where the dense vegetation covered was the lowest temperature due to urban heat signature, air surface temperature, and perception study. On the other hand, the resident as different compared to students of university campuses, both UM and UI campuses, as a human being in the urban area and university area.

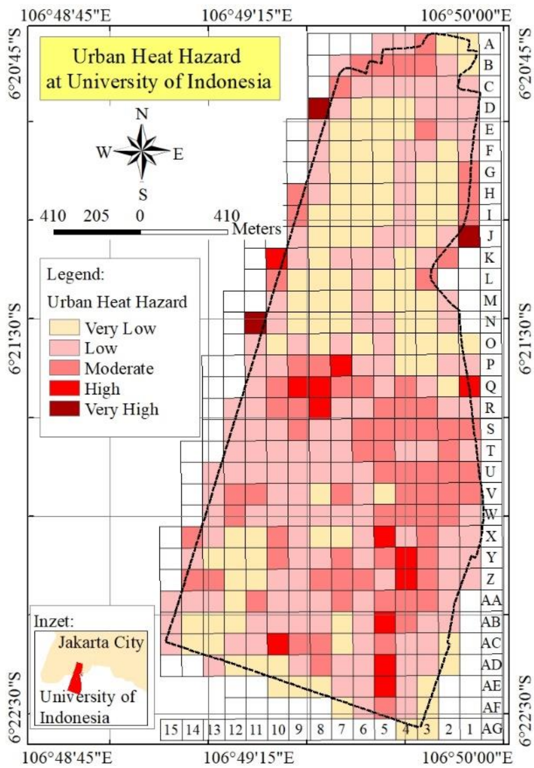

Fig.6 Urban Heat Hazard Map on UI Campus.

Land cover change is a key problem threatening the natural ecosystem and creates vulnerability to an environmental hazard [28]. The research agrees with Bekele et al., with the results explained the land cover changes on UM and UI campuses. These changes will generate the heat hazard on the university campus as Urban Heat Hazard Threat.

Generally, cities face typical urban events due to the urban setting that can alter the local microclimate with higher impacts [29]. Urbanization increases the risk of extreme heat episodes in Europe's cities due to the loss of urban green space [30]. That spatial-temporal detecting land cover changed much importance [31]. This research agrees with Ashaolu et al. to detect the land cover changed. Urban outdoor environments, including university campuses, particularly in the tropics, largely depend on their frequency of use, which can be profoundly altered by the level of outdoor thermal comfort [32]. This research agreed with Ghaffarianhoseini et al. That the research detecting land cover changed the effect on urban heat and impact on air surface temperature as thermal comfort.

Finally, the novelty of the result is that the research improved the impact of urban heat hazard based on urban heat signatures, air surface temperature, and perception study. The result concluded that sun heat generated urban heat signatures, the effect on air surface temperature, and impact on humans or students on the university campus as a definition of urban heat hazard threat.

4. CONCLUSION

The study concludes that increased temperature above the threshold is causing by land cover change on tropical university campuses. The temperature of Urban Heat Signature, Air Surface Temperature, and Perception Study of Heat concludes that a combination of three aspects (overlaid) generated an Urban Heat Hazard on tropical university campuses. Both UM and UI campuses had a distribution of the urban heat hazards related to paved open space and building covered. The study concludes that urban heat hazard threat is causing by temperature above a threshold based on landcover types on tropical university campuses.

5. ACKNOWLEDGMENTS

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