

# Knowledge Exploration Study of Muhammadiyah School Students about Urban Heat Island Threats in Surakarta City

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**Abstract** - This study aims to determine the knowledge of school students on the threat of Urban Heat Island (UHI) in Surakarta City. This study uses a quantitative descriptive approach with survey methods and image interpretation. This study aims to determine the threat of UHI in Surakarta through image interpretation and to find out the knowledge about UHI, the causes of UHI, and the impact of UHI in daily life by students in schools. The study sample were Seventh Grade students of Surakarta Muhammadiyah 1 Junior High School located in the center of Surakarta City and Seventh Grade students of Surakarta 10 Muhammadiyah Junior High School located on the outskirts of Surakarta. The results showed that Surakarta City was identified to be threatened by UHI phenomena from the interpretation of Landsat 7 ETM + images where the NDVI (Normalize Difference Vegetation Index) from 2003 to 2015 accounted to -0.4491 and the LST (Land Surface Temperature) index showed an increase in high temperature of 34-35 ° C in Surakarta City in 2015. Validation test on instruments shows the value of  $r_{count} > 0.444$ , meanwhile the Cronbach's Alpha value is 0.635 > 0.444. Finally, the questionnaire can be declared to be reliable to use. Based on interviews with students thru validated instruments, it can be concluded as follow: 81.5% of students did not know that UHI was threatened the city, 59% of students felt that there was an increase in heat in the Surakarta city area at the time at night lately, 53% of students know that the temperature of Surakarta City is currently hotter than the districts around the City, 57.4% of students know the causes of urban temperature changes lately, 30.6% of students know the impact caused by the UHI phenomenon.

**Keyword:** Urban Heat Island, NDVI, LST, Student

## I. INTRODUCTION

City is characterized by its morphology which dominated by impermeable built area. Heavily built area results in disruption of city's ecological balance. The density of buildings in urban areas has an effect on the micro climate of city. There is highly significant relationship between LCZs (Local Climate Zone classification) and the UHII (Urban Heat Island Intensity) for a given urban agglomeration (Long *et al.*, 2018). The increase of city's size and the proportion of locally developed land both contributed to urban warming, but their relative importance changed over time and varied seasonally (Hu,

Xiaofang, et al, 2017). Chapman et al, (2017) stated that urban growth was found to have a large impact on local temperatures, in some cases by up to 5 °C in North-East USA.

Surakarta City is one of the big cities in Central Java Province which has a strategic location where it is the junction node of the Surabaya-Semarang and Surabaya-Yogyakarta highway route. The route is a national one that has a high density of activity. The area of Surakarta City reaches 44.04 km<sup>2</sup> which administratively consists of 5 sub-districts, i.e.: District of Laweyan, Serengan, Pasar Kliwon, Jebres and Banjarsari. The city of Surakarta is currently experiencing rapid urban development which is indicated by the increasing of settlement as a result of the increasing population. The residential area of Surakarta City has increased by 3.66% from 2007 to 2011 (Bappeda, 2011).

Susilawati (2016) states that Surakarta City has been threatened by urban heat island hazards indicated by the results of the Normalize Difference Vegetation Index (NDVI) and LST (Land Surface Temperature) analysis. NDVI of Surakarta City in 2003–2011 was at a low index of -0.491 means that there is almost no vegetation (vegetation density is very low therefore more dominated by settlement), while based on LST analysis on Landsat 7 images in 2003 shows the average surface temperature of Surakarta City was 33.1 °C - 35 °C and increased to 36 °C - 37 °C in 2011.

Based on the phenomenon of changes in the conditions of the Surakarta City's micro climatic conditions above, students are one of the vulnerable groups to disaster, students are also one of the educated components in the community that can be involved in disaster mitigation, one of which is mitigation of Urban Heat Island. UHI's knowledge in the school is needed to be able to create empathy for the school especially students to get involved in reducing the disruption of the urban microclimate. The shaping of students' character through the participation model will improve the environment sense belonging so that students can act as UHI mitigators. The high commitment to create a Child-Friendly Surakarta in a sustainable manner is also an appropriate stimulation to involve students to participate in Urban Heat Island mitigation which is threatening them. One form of mitigation is UHI's one that threatens

the people of Surakarta City which can be approached through learning at school.

This study aims to determine the threat of UHI in Surakarta, and to know the knowledge of the threat of UHI for students in Surakarta City schools.

## II. THEORETICAL BACKGROUND

### A. Definition of Urban Heat Island

Freitas, E.D (2007) suggested that the Urban Heat Island is related to heat stored which concentrated on asphalt and causes hot temperatures up to late afternoon in a city compared to areas outside the surrounding city. Urban Heat Island is caused by industrialization, transportation and building materials that contribute to warming. Compendium of Strategies, U.S.EPA (2008) suggests that Urban Heat Island is a condition that urban area is warmer than the surroundings. Urban Heat Island occurs because of the reduction of vegetation in the city and the increase in buildings, paving, asphalt and cement. In addition, Urban Heat Island is also caused by an increase in production of exhaust gases of motor vehicles and air conditioners (AC).

### B. Measurement of Urban Heat Island

Dwevedi (2014) divides the two types of Urban Heat Island, namely (1) Canopy layer urban heat islands (UCL) is the canopy layer on Urban Heat Island which is located on the layer where humans live from the ground to the roof and trees, (2) Boundaries layer urban heat islands (UBL) is an urban heat layer starting from the roof and top of a tree reaching a point where the city has not been influenced by the atmosphere. This type usually reaches a limit of approximately 1.5 km from the surface. Today, measuring Urban Heat Island can be conducted by remote sensing techniques. Remote sensing images can provide spatial temperature information for cities. Measurement of UBL and UCL can be done by remote sensing techniques.

### C. Mitigation of Urban Heat Island

The impact caused by Urban Heat Island is not only increasing of the temperature of the city, but also causing pollutant trapping so that it could reduce the air quality of the city. Healthy Air Living (2011) explained that Urban Heat Island mitigation efforts to reduce temperature can be done by (1) tree and vegetation planting, (2) cooler roof, (3) light pavement (light colored paving) and (4) green roofs.

### D. Exploratory Research

Exploring information on knowledge of students of Junior High School about the threat of UHI is done by exploration methods, which at this stage acts as a searching and stabilization of concepts. Data collection techniques was using interviews both closed and open one. Suharsimi (2010) states that exploratory research is a study to explore the causes of things that occur

## III. EXPERIMENTAL METHODS

This research is an exploratory research to explore UHI's knowledge of students, and analysis of UHI threats in Surakarta City which is done through NDVI analysis and LST through imagery.

- 1) UHI threats was identified in Surakarta City through the Normalize Difference Vegetation Index (NDVI) and Land Surface Temperature (LST). NDVI and LST measurements in 2003, 2011 and 2015 were based on Landsat 7 ETM + images, administrative maps of Surakarta City, and groundcheck points. The analysis was carried out using Erdas software and statistical analysis and layouting using ArcGIS 10.2 software.
- 2) Learners' knowledge of the threat of disasters in Surakarta City was explored by digging information about the knowledge of students at the school on the threat of UHI. The digging of students' knowledge in schools was done by exploration methods, which at this stage were the searching and consolidation of concepts. Data collection techniques was using interviews both closed and open one.

### A. Variables of the Research

The research focus point or referred to as the research variable (Suharsimi, 2010) in this study is the threat of UHI in the City of Surakarta, and students' knowledge of the threat of disasters in Surakarta City.

The knowledge variables of the UHI threat in Surakarta City include :

1. Knowledge of the threat of UHI in Surakarta City
2. Knowledge of recent temperature changes
3. Knowledge that Surakarta City is relatively hotter than the surrounding area
4. Knowledge of the effects caused by UHI
5. Knowledge of the importance of UHI knowledge in schools.

### B. Population and Sample

Population is a generalization area consisting of objects / subjects that have certain qualities and characteristics that are determined and studied by researchers and then conclusions was drawn (Sugiyono, 2017). The population in this study were Seventh Grade students of SMP 1 Muhammadiyah Surakarta and Seventh Grade students of SMP 10 Muhammadiyah Surakarta, totaling 216 students. The sample used in this study was 50%, as many as 108 students. The sample school is a school located in the centre of Surakarta City.

### C. Data Acquisition Technique

UHI threat data in Surakarta City in the form of secondary data was obtained through interpretation of Landsat ETM 7+images, while data collection on students' knowledge of the UHI threat was using questionnaires. Suharsimi (2010) suggests that questionnaires are a number of written questions to get information from respondents about things that are known by respondents. This study uses a closed and open questionnaire with variables including: knowledge of

UHI threats in Surakarta, the causes of UHI threats, and the impact of the UHI phenomenon.

#### D. Data Analysis Technique

Data analysis techniques in this study include:

##### 1) Instrument's Validation Test Results

Validation test was conducted to find out valid indicators so that they can be used as research instruments. Based on the significance level of 0.05 with a value of  $n = 20$ , the obtained  $r$  table value is 0.444. The indicator is declared valid if  $r \text{ Count} > r \text{ 0.444}$ , where validation testing uses this Pearson moment product analysis.

Table 1. Instrument Validation Test Results

No	r Hitung	Hasil
1	0.490	Valid
2	0.186	Not Valid
3	0.450	Valid
4	-0.286	Not Valid
5	0.437	Not Valid
6	0.572	Valid
7	0	Not Valid
8	0.593	Valid
9	0	Not Valid
10	0.610	Valid
11	0.457	Valid
12	-0.03	Not Valid

Source: Author, 2019

The results of the instrument validation test show that of the 12 tested indicators, there are 6 indicators that can be declared "valid". Valid indicators include: (1) Knowledge of Urban Heat Island Phenomena (UHI) that threaten urban areas, (2) Feel that there is a rise in heat temperature in the Surakarta city area at night lately, (3) Knowledge of Surakarta City is recently has a hotter temperature than the districts around the City, (4) The causes of urban temperature changes lately, (5) the impact caused by the UHI phenomenon, (6) Urban Heat Island Phenomena (UHI) need to be introduced in school to students.

##### 2) Instrument Reliability Test Results

Reliability testing is conducted to determine consistency of the research indicators (list of questions in the questionnaire). Reliability testing will produce relatively similar measurements. Test reliability was using a test from Cronbach's alpha with N number 20.

Table 2. Instrument Reliability Test Results

Cronbach's alpha	N items
0.635	20

Source: Author, 2019

The reliability test result using Cronbach's alpha show that Cronbach's alpha = 0.635. Based on a significant level of 0.05 with N number 20, the obtained  $r$  table was of 0.44. Then the calculation results show that  $0.635 >$

0.444 meaning the instruments used in this study are reliable and can be used as research instruments.

##### 3) Knowledge Level of UHI Threats

This descriptive analysis uses the percentage of data results obtained from the questionnaire.

## IV. RESULTS AND DISCUSSION

### A. UHI Threats in Surakarta City

Surakarta City is one of the big cities in Central Java which is a magnet for the surrounding small towns. The geographical conditions of Surakarta City determine the development of this city and its surroundings. The location of Surakarta City is on the inter-mountainbasin which is a low-lying area between the two mountains (Mount Merapi and Mount Lawu) making the Surakarta City is not having a topographical obstacle in the development of the city.

The increase in population with a fixed area resulted in a high population density. BPS's data in 2011 stated that the population density of Surakarta City reached 13.354 people / km<sup>2</sup>. The increase in the population of Surakarta City has led to an increase in the need for buildings so that there is less open land.

##### 1) Changes in the Use of Land in Surakarta City

Changes in the land use of Surakarta City indicated an increase in open land and a decrease in built-up land, based on the following data from Citra Landsat ETM 7+, of year 2003, 2011 and 2015:

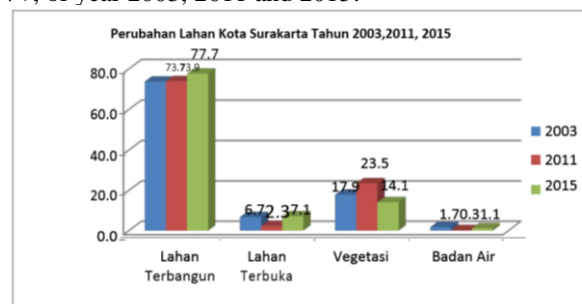


Figure 1. Land Use of Surakarta City in 2003, 2011 and 2015

Source: Landsat Image Processing 2003, 2011, 2015

Based on Figure 3, vegetation increased in 2011, the increase in vegetation in that period was influenced by the Surakarta City Government's policy on Green Open Space, where the City Government fixed and created Green Open Space in border areas, city parks, and green lanes highway. However, the decline in vegetation was drastically occurred in 2015, where vegetation was only around 14%.

##### 2) Identification of UHI Threats through NDVI Interpretation and LST

###### a. Normalize Difference Vegetation Index (NDVI) of Surakarta City

The identification of UHI threats in Surakarta City was carried out through analysis of Landsat 7 ETM + of Surakarta City images in 2003, 2011 and 2015. Analysis was carried out on the Normalize Difference Vegetation



Index (NDVI) and Land surface temperature (LST). NDVI is used as an UHI identification parameter because through NDVI it can be known the reflection value of an infrared band reflected by photosynthetic plants, spatially the infrared band reflection shows vegetation density in an area. Based on the classification based on the value (wavelength /  $\mu\text{m}$ ) NDVI, Franklin 2001 divides in the following categories :

Table 3. Vegetation density and NDVI value

Vegetation density	Value of NDVI ( $\mu\text{m}$ )
Very good	0.72-0.92
Good	0.42-0.72
Normal	0.22-0.42
Bad	0.12-0.22
Very Bad	-0.1-0.22

Source: Franklin, 2001

Based on the NDVI analysis of Surakarta City for 3 years, the period 2003 - 2015 shows a real change as a result of the influence of land changes in that period. NDVI Surakarta City in that period indexed  $<-0,1$  which means that this condition is very bad, vegetation density in Surakarta City is very low.

Table 4. NDVI Surakarta City Year 2003, 2011, and 2015

Sub-District	Year 2003	Year 2011	Year 2015
Banjarsari	-0.109	-0.185	-0.455
Jebres	-0.052	-0.162	-0.422
Laweyan	-0.159	-0.194	-0.454
Pasar Kliwon	-0.183	-0.211	-0.549
Serengan	-0.203	-0.224	-0.574
Average of Surakarta City	-0.141	-0.195	-0.491

Sumber:...

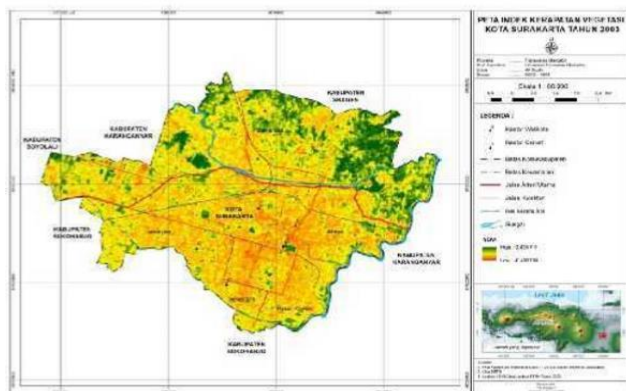


Figure 2. NDVI's Map of Surakarta City in Year 2003  
Source : Landsat Image Processing ETM 7+, 2003

The NDVI analysis shows that the distribution of low vegetation density in Surakarta City is evenly distributed throughout the city with the lowest density is in Serengan District. Based on the Landsat ETM +7 image in 2003 above, the distribution of vegetation in Surakarta is still found in the northern part, while the central and southern Surakarta areas have very poor vegetation density.

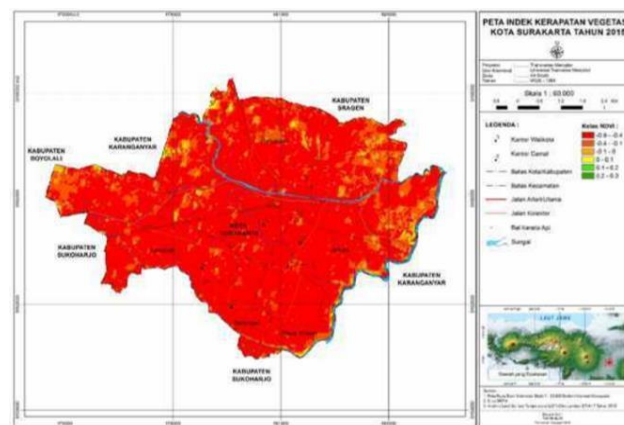


Figure 3. NDVI's Maps of Surakarta City Year 2015  
Source : Landsat Image Processing 2015

The picture above shows the NDVI map of Surakarta City in 2015 where the overall area in Surakarta City was at the NDVI index  $-0,1-0,22$  which means that vegetation density was very poor.

#### b. Land surface temperature (LST) of Surakarta City

The identification of UHI threats in Surakarta City was also analyzed from surface temperature based on thermal bands on Landsat ETM 7+ imagery on channel 6. Surakarta City's LST in 2003, 2011 and 2015 experienced a trend shift. Figure 6 shows LST Lines of Surakarta City in 2003, 2011 and 2015 with the highest temperature area in 2003 of  $25-26^{\circ}\text{C}$ , to  $31-32^{\circ}\text{C}$  in 2011 and increased to  $34-35^{\circ}\text{C}$  in 2015. Increased temperature as high as  $34-35^{\circ}\text{C}$  in 2015 indicate the threat of UHI in the Surakarta City area.

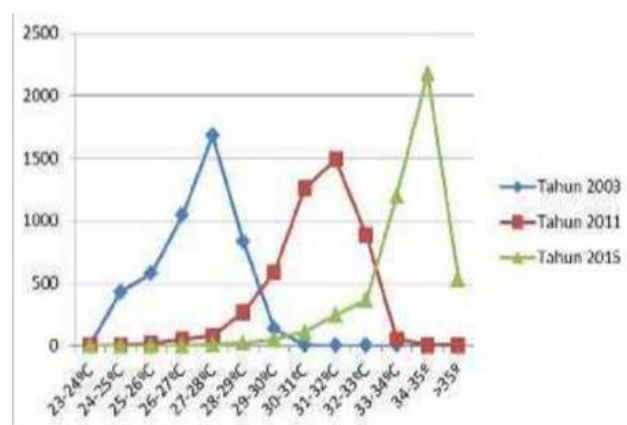


Figure 4. Graph of LST of Surakarta City in Year 2003, 2011 dan 2015  
Source : Landsat Image Processing ETM 7+, 2003, 2011, 2015

Surakarta City LST during the period of 2003 - 2015 spatially follows the trend of land cover changes expressed through NDVI. The average LST with high temperatures were Pasar Kliwon, Serengan and Laweyan Subdistricts, while the LST with relatively low were in the two sub-districts in the north and east of Surakarta City, i.e. Banjarsari and Jebres Subdistricts

### B. Knowledge of UHI Threats for Students at Muhammadiyah Schools in Surakarta City

UHI is caused by urban development (urbanization), an increase in the structure of land cover and land cover changes such as industrialization (Rizwan et al, 2008). Furthermore, Ward et al. (2016) stated that the impact of UHI is the high temperature of urban areas compared to the surrounding area, even this increase in temperature is accompanied by changes in the pattern of rain, and extreme climate. The impact caused by UHI in urban areas affects human activities including discomfort (human discomfort).

Based on the impact of UHI on humans above, UHI's knowledge in the school environment is very necessary. Knowledge of UHI by students can improve preparedness and even students can be invited to be involved in reducing disruption of urban microclimate.

#### 1) Learners' Knowledge in Muhammadiyah Schools in Surakarta City for Urban Heat Island Phenomena

UHI's knowledge of Muhammadiyah Junior High School students in Surakarta City can be shown in the diagram as follows:

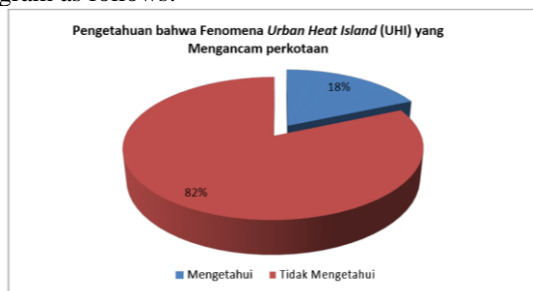


Figure 5. Learner's Knowledge Diagram of the UHI Phenomenon

Source: Author, 2019

Based on the diagram above it can be seen that students who know that the phenomenon of Urban Heat Island (UHI) can threaten the city by were 18%, while 82% indicate that students were not aware of the threat to the city with the UHI phenomenon.

#### 2) Changes in Night Temperature in Surakarta City

Knowledge of Muhammadiyah School students in Surakarta City regarding changes in nighttime temperatures in Surakarta City which can be shown by the diagram as follows:



Figure 6. Learner's Knowledge Chart of Changes in the Temperature of Surakarta City Night

Source: Author, 2019

Based on the above diagram it can be seen that as many as 41% of students did not feel that there was an increase in nighttime temperatures in Surakarta City, while as many as 59% of students felt that there was an increase in nighttime temperatures in Surakarta City.

#### 3) Knowledge of Temperature Increase in Surakarta City compared to the surrounding Regencies

The knowledge of Muhammadiyah School students in Surakarta City regarding the differences in temperature rise in Surakarta City and the surrounding districts can be shown with a diagram as follows:



Figure 7. Learners' Knowledge Chart of the Differences in Temperature Increase in Surakarta City with Districts Around It

Source: Author, 2019

Based on the diagram above, it shows that as many as 47% of students know that there is a difference in temperature rise in Surakarta City with surrounding districts, while as many as 53% of students do not know if there is a temperature difference between Surakarta City and the surrounding districts..

#### 4) Knowledge of Impacts Caused by UHI

The knowledge of Muhammadiyah School students in Surakarta City on the effects that can be caused by the UHI phenomenon can be shown as follows:

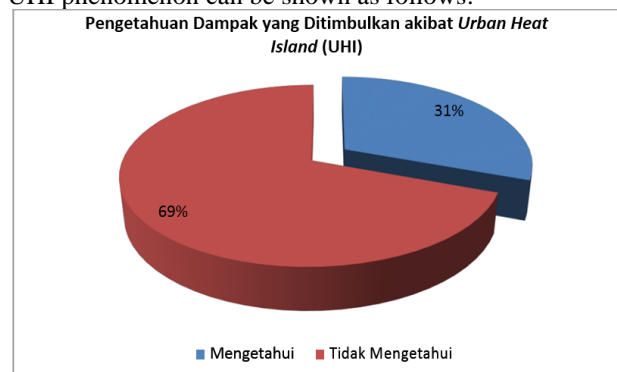


Figure 8. Learners' Knowledge Chart of the Impacts That Can Be Caused by the UHI Phenomenon

Source: Author, 2019

Based on the diagram above, it shows that as many as 31% of students know the impact that can be caused due to the UHI phenomenon, while 69% of students do not know the impact that can be caused from the UHI phenomenon that occurs.

##### 5) Student Statement that UHI needs to be introduced to the School

The statement of Muhammadiyah School students in Surakarta City regarding the UHI phenomenon that needs to be introduced to school can be shown as follows:

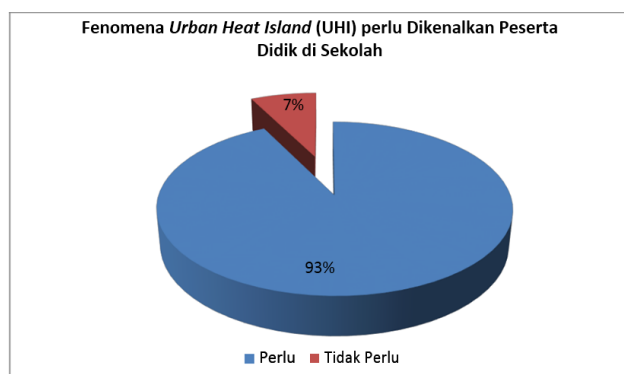


Figure 9. Diagram of Students' Statement Regarding the Need for Introduction to UHI in Schools

Source: Author, 2019

Based on the diagram above shows that 7% of students stated that there was no need for an introduction to the UHI phenomenon, while 93% of students stated that there was a need to introduce material about the UHI phenomenon in school.

## V. CONCLUSION

Based on the results of the research as described above, it can be concluded as follows:

1. The existence of UHI threats in Surakarta City can be known by the increase in population, changes in land use, and based on identification through the interpretation of NDVI and LST.
2. The students' knowledge about UHI in Surakarta City is still low, so there needs to be an introduction to the UHI phenomenon in schools.

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