





Urban Heat Island Literacy Among Geography Education Students of Universitas Muhammadiyah Surakarta

Siti Azizah Susilawati^{1,2*} , Mohd Hairy Ibrahim² , Nor Kalsum binti Md Isa² , M. Musyiam¹, Nanda Khoirunisa³ 

¹Department Geography Education, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta, Indonesia

²Faculty of Social and Humanities, Sultan Idris Education University, University Sultan Idris, Malaysia

³Department Geophysics, Faculty of Mathematics and Natural Sciences, Universitas Mulawarman, Indonesia

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Corresponding Author

E-mail:

azizah.susilawati@ums.ac.id

ABSTRACT

Geography Education students are expected to have literacy about the phenomena around them, one of which is Urban Heat Island (UHI) literacy. It is appropriate by the mission of Geography Education at the Muhammadiyah University of Surakarta (UMS) is to produce geography educators with a view on disaster mitigation. This study aims to determine the UHI literacy of students in 7th semester, Department Geography Education, Faculty of Teacher Training and Education, Universitas Muhammadiyah Surakarta. This research is a quantitative descriptive study with survey methods. The study using purposive random sampling of 80 respondents and as many as 54 collage students were selected as samples. The UHI literacy research instrument was developed based on the OECD's International Program for Student Assessment (PISA) in 1999. Based on the indicators in scientific literacy which are divided into three categories, the results are obtained: 1) Indicators of UHI's concepts show that high categories are middle class 20.4 % and the majority of students at a high level with 79.6%; 2) Indicators of UHI's processes obtained results with 1.8 % of students at a low level, 20.4 % of students at a medium level, and 78.8 % at a high level; 3) UHI's situation indicators showed that the high category was 93% and moderate was 7%. The conclusion shows that the UHI literacy of students is relatively high, indicating that curriculum based on disaster insight has been doing well, but further research is needed on other disaster insights and analysis of factors which affect the results above.

INTRODUCTION

The urban heat island phenomenon is one of the effects caused by climate change in a metropolitan area. The impact of global warming in urban areas is the rising urban temperature, known as the Urban Heat Island (UHI) phenomenon; UHI is a phenomenon that occurs when urban temperatures are higher than those in suburban areas (Masumoto, 2015). UHI is part of climate change that needs a portion to be concerned. The phenomenon shows that cities are almost warmer than their surroundings, as evidenced by inadvertent

climate modification due to human activities (Oke et al., 2017). The effect can be seen in less dense fog and an increased smog rate in the central city. The study of urban heat island hazards also used university campuses' research location as a smaller city, which showed the same pattern as an actual city with the built-up area as the highest temperature field (Wibowo et al., 2017).

Formal education systems for climate change education can be significant and effective methods of developing capacities

for addressing the climate crisis. Still, more time and adequate development of curriculum opportunities in the classroom indicate the need to use co-curricular and community efforts for students (Stevenson et al., 2017). Previous studies show American teens have a better understanding of climate change than adults on a few crucial measures; however, a graduate student in the USA indicates even if they find that there are several climate courses, most students feel not obtaining depth and a vast breadth of climate change education (Kuster & Fox, 2017). Other studies have captured misconceptions, misunderstandings, and confusion regarding complex information and knowledge, which continues to be widespread due to the complexity of the climate change topic (Leiserowitz et al., 2011). Mitigating climate change through education is progressively acknowledged, but the education sector continues to be underutilising as a crucial and strategic asset.

Teachers must encourage students to think about climate change mitigation and adaptation to develop their capacity to respond with meaningful actions and play a critical role in promoting scientific literacy (Plutzer & Hannah, 2018; Valdez et al., 2017). The climate change literacy trend

Urban Heat Island (UHI)

The urban heat island phenomenon is one of the impacts caused by climate change in urban areas. The effects of global warming in urban areas are the increase in urban temperatures, known as the urban heat island phenomenon. The urban heat island phenomenon is a phenomenon that happens when urban temperatures are higher than in suburban areas Field (Masumoto, 2015). **Figure 1** illustrates the urban heat island phenomenon: a high temperature in a metropolitan area and a gradual decrease in a rural area.

aims to help the public understand global climate change information, causes, effects, and responsible actions in response to climate change impacts. For example, the Pacific community is raising improved climate literacy to respond to the environment by integrating all aspects across the school curriculum to apply climate change education. Integrating climate science in some courses proves that it can increase the knowledge of climate change in the student field (Khoirunisa & Susilawati, 2019; Versprille et al., 2017). with the student as central learning and positive relationships among students, as well as between teachers and students, along with developing and strengthening classroom rules (Mukminan, 2018).

The investigation regarding climate change literacy has become the main topic in recent years; however, the same study-related urban heat island still needs to be found, making this study urgent. University students do not realise they are already victims of urban heat island phenomena around their environment. As a future teacher in the geography education field, which is the primary source of urban heat island and climate change knowledge in Indonesia's education system, the obligation to have literacy about the topic is essential.

It is imperative to address UHI as they significantly impact the environment, including rising air temperatures, changes in precipitation patterns, and other meteorological conditions. UHI exacerbate air quality because, in conjunction with the escalation of fossil fuel consumption, they contribute to the release of greenhouse gases (CO₂) and other pollutants, including nitrogen oxides (NO_x) and Sulphur dioxide (SO₂). The contaminants contribute to the greenhouse effect's existence.

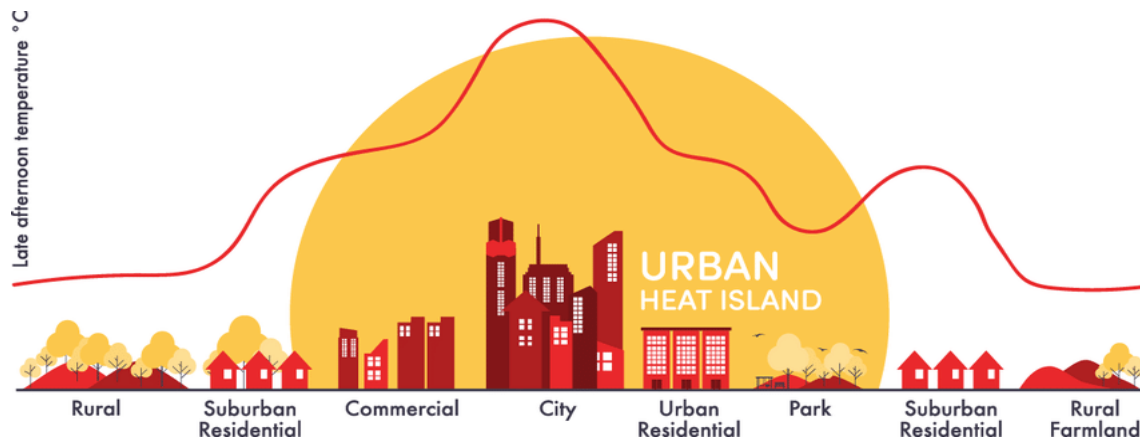


Figure 1. Profile and Temperature Effect of Urban Heat Island (Source: Fuladlu et al., 2018)

An investigation of more than 3700 published papers about the urban heat island phenomenon was recognised in the Web of Science Database for a long time from 1989 to 2016 and was grouped in a few fields of science. The more significant part of published papers was recognised in the meteorology field (26%), environmental

science (19%), engineering and remote sensing (11%), and building technology (10%), at that point followed by papers written in energy, geology, physical geography and urban structure (Ana-Maria et al., 2016). The complete profile of the urban heat island study in the different research areas is shown in Figure 2.

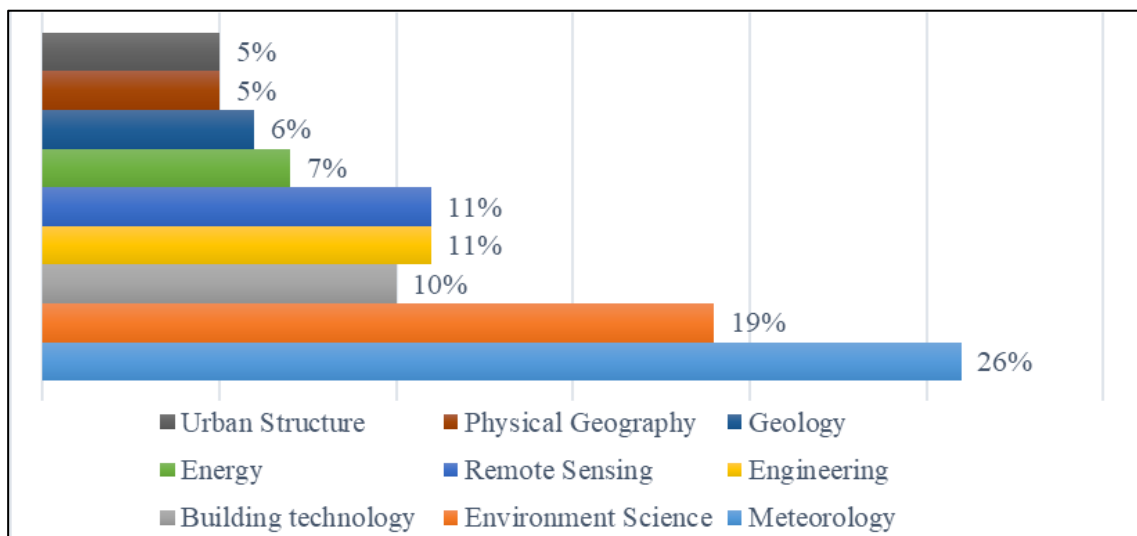


Figure 2. Urban heat island study in different research areas in 1989-2016 (Source: Ana-Maria et al., 2016)

The urban heat island phenomenon in Indonesia has been identified in several major cities in Indonesia. Urban heat island threats occur in big cities on Java Island, namely Jakarta, Bandung, Semarang, Surakarta, Yogyakarta, and Surabaya,

published by 27 papers between 2012 and 2019 (Table 1). The literature review is derived from accredited international and national journals in Indonesia, and research has been published at conferences.

Table 1. Urban heat island study in Indonesia (2012-2019)

Location	Aim and Objectives	Method	Publication
Jakarta, Depok, Tangerang	UHI measurement	Interpretation of Landsat Imagery (NDVI, NDBI and LST)	(Prasasti et al., 2015; M. I. J. Putra et al., 2018; Rushayati et al., 2016; Wibowo & Rustanto, 2013)
		Temperature field measurement	(Manik & Syaukat, 2015)
	Influence factor of UHI phenomena	WRF (Weather Research Forecasting), Delphi and Python Modification	(Tursilowati et al., 2012)
	UHI Mitigation	Secondary data review	(Limas et al., 2014)
	Impact of UHI	Prediction of rainfall and aerosol based on Mann- Kendall analysis	(Syamsudin & Lestari, 2017)
Bandung	UHI measurement	Interpretation of Landsat Imagery (NDVI, NDBI and LST)	(Fardani et al., 2018; Fitria et al., 2019; Naf & Hernawati, 2018; Ningrum & Narulita, 2018)
	Effect of UHI	CDD (cooling degree days)	(Arifwidodo et al., 2019)
Semarang	UHI measurement	Interpretation of Landsat Imagery (NDVI, NDBI and LST)	(Darlina et al., 2018; Delarizka et al., 2016; Pamungkas et al., 2019; Sasmito & Suprayogi, 2017)
	UHI Mitigation	Field observation and Landsat imagery interpretation	(Luthfiyyah & Widjajanti, 2019)
Yogyakarta	UHI measurement	Interpretation of Landsat Imagery (NDVI, NDBI and LST)	(Fawzi, 2017; Husna et al., 2018; Suarna et al., 2019; Wicahyani et al., 2014)
Surabaya	UHI measurement	Interpretation of Landsat Imagery (NDVI, NDBI and LST)	(Jatayu & Susetyo, 2017; Sobirin & Fatimah, 2015)
Surakarta	UHI measurement	Interpretation of Landsat Imagery (NDVI, NDBI and LST)	(Baroroh & Pangi, 2018; A. K. Putra et al., 2018; Wulandari & Sudibyakto, 2017)

Based on the literature review, UHI research with the theme UHI measurement is 81.5%, UHI effects and impacts are 11.1%. Influence factors and mitigation of UHI is 14.8%, while based on research location it shows that UHI has occurred in cities as follows: Jakarta, Depok, and Tangerang (Jabodetabek), Bandung, Semarang, Yogyakarta, Surabaya, and Surakarta

(**Figure 3**). The literature review above shows that research on the theme of UHI has been carried out in big cities in Indonesia, with various issues, but no UHI knowledge has been found in the field of education. Knowledge of UHI is needed for geography education students because UHI is one of the geosphere phenomena that occur around students.

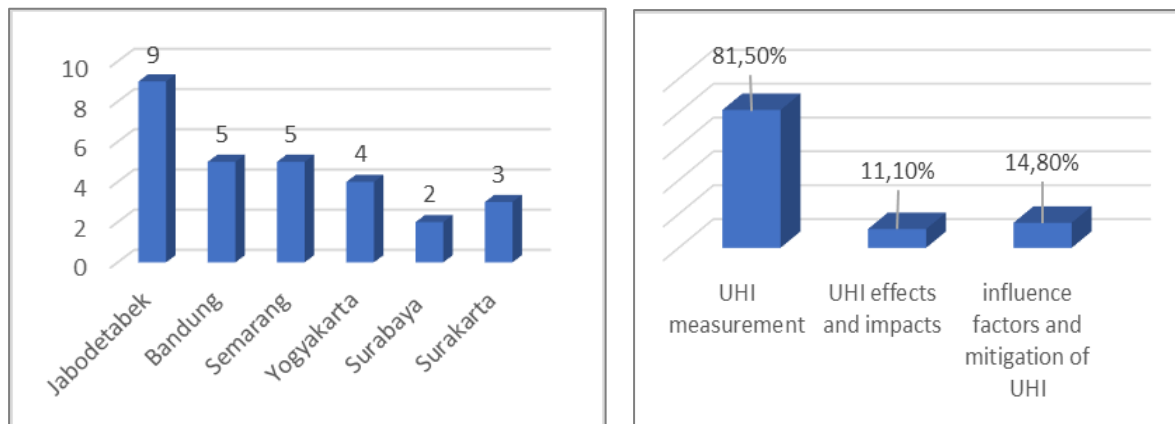


Figure 3. UHI researches in Indonesia based on the research location and UHI theme

Education Sustainable Development (ESD) and Climate Change Education for Sustainable Development (CCESD)

In light of Sustainable Development Goals (SDGs) objectives by 2030, education is an essential foundation for accomplishing these goals, including Goal 13 in climate action. Education for Sustainable Development (ESD) is education that transforms knowledge, aptitudes, attitudes, and qualities to arrive at supportable among society. The Sustainable Development Goals is a secure platform for a broad curricular methodology that has been built up. Sustainable Development Goals (SDGs) require four skills beyond literacy and numeracy-including readiness for primary education, specialized and professional abilities, and abilities expected to advance global citizenship and sustainable development. Mainstreaming climate change education through formal education systems can be one of the most critical and successful methods of developing capacities concerning tending to the climate crisis. It is because of multiplier impacts, where families and communities advantage when people share what they have learned, especially about adaptation and mitigation (MoChizuki & Bryan, 2015). As an urban climate phenomenon, UHI has been extensively investigated in temperate regions (Lazzarini et al., 2015).

Principles of CCE in the ESD context, or Climate Change Education for Sustainable Development (CCESD), requires an upgrade of students' understanding of climate change's causes and impacts and

readiness to address it. The principles of CCESD are sorting out information knowledge, skills, attitudes, dispositions, and competencies to be fostered through it (Trajber & Mochizuki, 2015). Therefore, Climate Change Education for Sustainable Development (CCESD) has a central role in helping the general public and especially the next generations, understand and relate to the issues, make lifestyle changes to reduce greenhouse gas emissions and adapt to the changing local conditions. The urban heat island (UHI) phenomenon is one of the effects caused by climate change in a metropolitan area. The impact of global warming in urban areas is the rising urban temperature, known as the Urban Heat Island (UHI) phenomenon; UHI is a phenomenon that occurs when urban temperatures are higher than those in suburban areas (Masumoto, 2015). The Climate Change Education for Sustainable Development involves improving students' understanding of a range of pedagogical theories and approaches about the causes and impact of climate change and a variety of attitudes, competencies, and skills that can be fostered.

RESEARCH METHODS

This study aims to determine the urban heat island literacy of students of the Geography Education, Teaching and Education Faculty at Muhammadiyah University of Surakarta (UMS). This research was conducted in Surakarta, especially in the Geography Education Department of the Muhammadiyah

University of Surakarta. This investigation involved a population of 80 students, namely 7th-semester students. The sample was taken by purposive random sampling 54 students where these students are students who have taken Meteorology and Climatology courses as a basic science in Urban Heat Island. This study uses the primary quantitative descriptive method, where quantitative data is converted into qualitative information based on criteria and finally interpreted.

In the development phase of the questionnaire, the Urban Heat Island Literacy research instrument was developed following the OECD's International Program for Student Assessment (PISA) in 1999. Based on the indicators of scientific literacy are divided into three indicators as follows: indicators of scientific concepts, scientific processes, and experimental situations, as listed in **Table 5**. In the feasibility phase, a questionnaire of urban heat island literacy was conducted through two statistic tests to finalize the instrument and its validation against students who have taken climatology meteorology courses in Geography Education. The instrument feasibility was tested by using the Product Moment Method for the validity test and reliability test using the Alpha Cronbach Method (Flora et al., 2014; Valdez et al., 2017). Data were obtained through the documents as well as questionnaires. The instruments were analyzed using the IBM SPSS computer programs for a validity and reliability test. The results were shown in percentages taken from the respondents' answers and transform into qualitative information.

RESULT AND DISCUSSION

The fact that UHI has happened around the world means this phenomenon is known by the general public. This research refers to the PISA 2015 scientific literacy definition. PISA define scientific literacy as the capacity to engage with science-related issues and with the ideas of science as a reflective citizen. A scientifically literate person is eager to take part in a reasoned talk about science and technology, which requires the competencies to (1) explain phenomena scientifically-perceive, offer and evaluate explanations for a range of natural and technological phenomena; (2) evaluate and design scientific enquiry-depict and appraise scientific investigations and propose methods of addressing questions scientifically; and (3) interpret data and evidence scientifically-analyses and evaluate data, cases and arguments in a various of representations and draw appropriate scientific conclusions.

Geography education students are responsible for being more literate about the phenomena that occur around them compared to other study programs, as well as geography education students of Universitas Muhammadiyah Surakarta (UMS). UMS is located in Surakarta city, the second biggest city in Central Java. Based on the literature review above, nowadays, Surakarta has indicated the UHI phenomena. Disaster knowledge and disaster literacy of geography education students should be possessed because it is by the vision and mission of Geography education of UMS. The vision and mission of Geography Education UMS are described below.

Table 2. Vision and Mission of Department Geography Education

Vision:	In 2029, it became a leading institution that upholds Islamic values in the administration of education, research, and community service in the field of geographic education with a view of Geographic Information Systems (GIS) and disaster mitigation and is able to provide direction for change.
Mission:	<ol style="list-style-type: none"> a. Organizing education to produce quality GIS-based geography educators and disaster mitigation that is of quality and in accordance with Islamic law b. Carry out research for the development of science and technology in the fields of education, GIS, and disaster mitigation c. Carry out community service activities that are able to give direction to change

The vision and mission of Geography Education UMS besides leading on education, research, and community service, the superior part is Students of Geography Education UMS have a view of Geographic Information Systems (GIS) and disaster mitigation. Disaster knowledge and disaster literacy of Geography Education UMS implemented on curriculum. There are many courses related UHI subject in curriculum's Geography Education of UMS, namely: (1) meteorology and climatology, (2) education of disaster mitigation, (3) practicum of disaster mitigation education, (4) climate change and global environment. Learning outcomes of Geography Education UMS oriented on a geographer capability and have a view on disaster mitigation. The basic knowledge's learning outcomes of Geography Education UMS are:

1. Mastering knowledge about the description, dynamics, and interdependence of atmospheric earth phenomenon, hydrosphere, lithosphere, pedosphere, and human activities.

2. Mastering the concepts and techniques of environmental and territorial analysis in a spatial context.
3. Mastering factual knowledge about the impact of development on the environment and disaster.

Based on explanation above, there was a reason why research on UHI literacy is needed among Geography Education students of UMS. The research sample is students who have taken meteorology and climatology course and the 7th semester level students, while students as samples for validation of instruments were students of all semester levels who have taken metrology and climatology course.

Validation of Instruments

The results of validation instrument of UHI literacy showed in **Table 3.** which revealed that all 12 items were valid. The table shows that the corrected-item total correlation is the correlation value of each item, which were all correlation values, are greater than r_{table} . The r_{table} value at the 0.05 significance with the number $n=50$ was 0.279. Based on the table shows that 12 items as a whole are counted $>r_{table}$ so that overall valid items are used as research instruments.

Table 3. Statistics of Validation Research Instrument

No	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation
1	45.16	34.015	.569
2	45.26	33.298	.634
3	44.82	33.661	.627
4	45.38	34.159	.622
5	45.46	34.335	.532
6	44.84	34.341	.522
7	44.52	34.500	.647
8	45.42	33.514	.584
9	44.70	34.173	.628
10	44.44	36.333	.573
11	44.36	35.500	.635
12	44.86	36.286	.449

Reliability of Instruments

Research instruments to measure the level of urban heat island literacy will be declared reliable if the calculation results of the reliability instrument are the same when

used to measure aspects several times or relatively the same. The above table shows the number of $N = 50$ with all the answers filled in, the meaning was 100% valid, while **Table 4.**, shows that the' questionnaire was

12 items with Cronbach's alpha value of 0.882, where this value means $0.882 > 0.279$, this indicates that overall reliable or consistent items' questionnaire.

Table 4. Results of Reliability Test of the Instrument

Case Processing Summary			Reliability Statistics		
		N	%	Cronbach's Alpha	N of Items
Cases	Valid	50	100.0	.882	12
	Excluded ^a	0	.0		
	Total	50	100.0		

Urban Heat Island Literacy of Geography Education Students

This research showed that the level of student's UHI literacy in Geography Education UMS tended to be high, even though it was spread in every indicator.

Linkert's scale analysis shows that 90.7 % of students have a high UHI literacy. In comparison, about 9.3 % have a medium level of UHI literacy, even if no one person has a low UHI literacy (**Figure 4**).

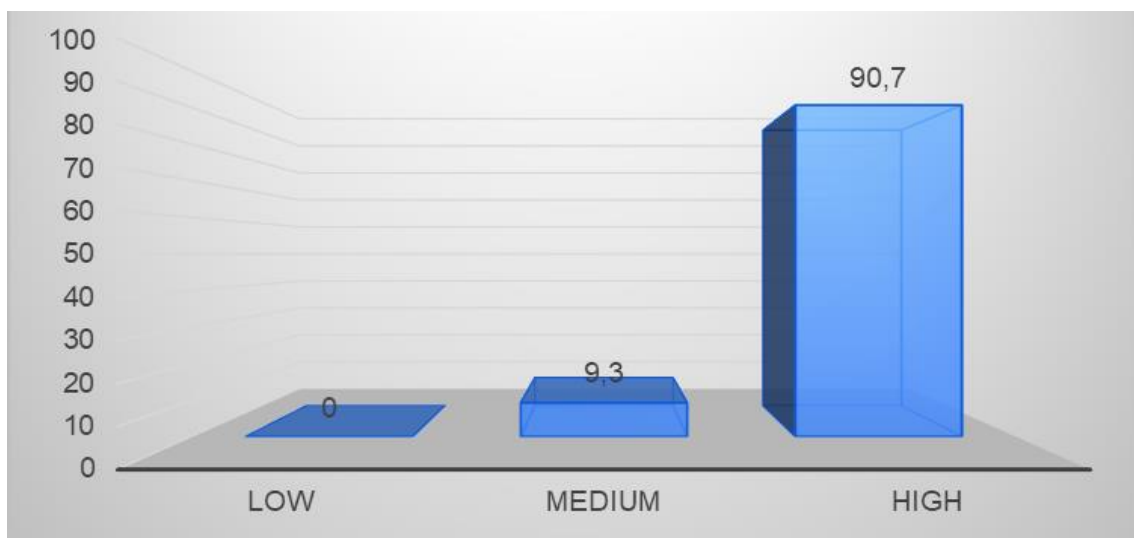


Figure 4. Percentage of UHI Literacy among Geography Education Student of UMS

The results of the study based on the type of indicators showed that the majority of UMS Geography Education students are at high UHI literacy levels. The concept indicators The UHI's concept indicator showed that there were 20.4 % students in the middle class and the majority of students at a high level with a percentage of 79,6 %. The UHI's process, there were 1.8 %

students who was at law level of UHI literacy, 20.4 % students at a medium level of UHI literacy, and 78.8 % were at high level of UHI literacy. Furthermore, the UHI's situation, only about 7 % students who were at medium level and the majority of students at 93 % were in high level of UHI literacy.

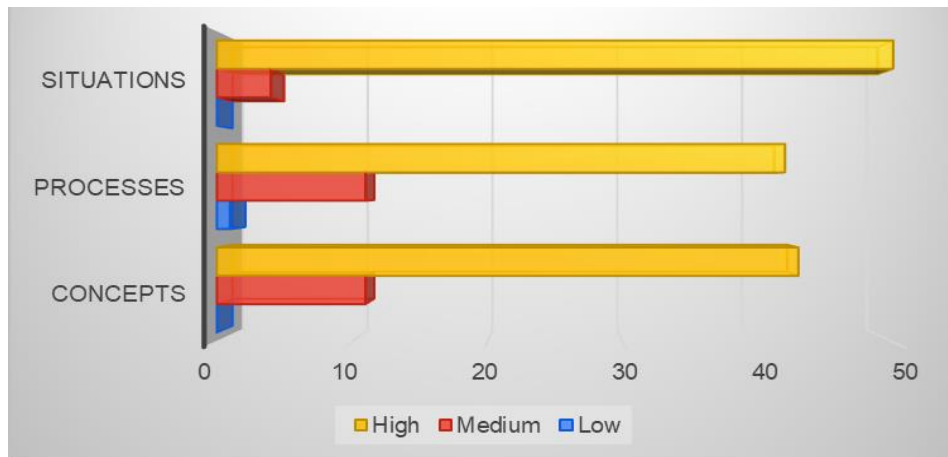


Figure 5. Urban Heat Island Literacy among Geography Students of UMS

Descriptive statistics distribution of UHI literacy Geography Education students of UMS is shown in Table 5. which reveals that the UHI literacy variable has a high trend based on distribution frequency. The high level of UHI literacy of Geography Students at

UMS can be seen from the mean score, which showed most of it more than 3.5 points. The majority of variables were on a high level. UHI's concepts were the lower type indicator among UHI literacy of students, followed the UHI's process, and then the highest was the UHI's situation.

Table 5. Statistic Descriptive of UHI Literacy among Students

UHI Indicators/variables	E		NA		N		A		V		Mean Score
	F	%	F	%	F	%	F	%	F	%	
UHI's Concept											
UHI knowledge	1	1.9	0	0	17	31.5	24	44.4	12	22.2	3.85
UHI as Climate Change impact	0	0	3	5.6	11	20.4	26	48.1	14	25.9	3.94
UHI is temperature changing in urban area	0	0	0	0	7	13	27	50	20	37	4.24
UHI's Process											
Influence factors of UHI	0	0	1	1.9	19	35.2	29	53.7	5	9.3	3.70
The area of UHI impact	0	0	3	5.6	22	40.7	22	40.7	7	13	3.61
Land use change	0	0	1	1.9	4	7.4	25	46.3	24	44.4	4.33
Temperature differences between urban & rural	0	0	1	1.9	1	1.9	16	29.6	36	66.7	4.61
UHI and sun radiation	0	0	3	5.6	19	35.2	23	42.6	9	16.7	3.70
UHI's Situation											
UHI impact in daily life	0	0	2	3.7	5	9.3	23	42.6	24	44.4	4.28
UHI knowledge is needed	0	0	0	0	5	9.3	14	25.9	35	64.8	4.56
UHI teaching learning at school	0	0	1	1.9	1	1.9	22	40.7	30	55.6	4.50
UHI knowledge as non-structural mitigation	0	0	0	0	8	14.8	28	51.9	18	33.3	4.19

Note: EA= Non-Agreeable A= Agree NK – Don't Know
 NA – Do Not Agree VA – Highly Agreeable F - Frequency

Based on the table above, the highest score was on the UHI's situation. The

variables of UHI's situation are more known and understood among students.

UHI impacts on daily life was more known by students. Students argued that teaching-learning media is needed to mitigate UHI phenomena. Furthermore, the highest score on UHI's process indicator was on understanding the temperature effect of UHI's area, followed by the effect of land use change on UHI phenomena.

Data analysis showed that many important factors affected UHI literacy among geography educators. Based on (Eryansyah et al., 2020), three group factors are involved in university students' literacy: the students themselves, the lecturer, and the campus. The campus or university provides facilities for college students to access literacy, of course, with easy and free access. Lecturer knowledge, interest, ability, and skills are also crucial factors in encouraging students to learn more about UHI. Department of Geography Education, Universitas Muhammadiyah Surakarta, trying to fill the knowledge gap by facilitating and seriously as stated in the curriculum.

The level of UHI literacy can be interpreted as college students having an initial provision in their efforts to adapt to climate change that occurs. Sources of information related to issues and phenomena that happen on this earth about global warming and climate change are currently elementary to obtain, especially from social media and the internet, also very much in line with the millennial generation and Generation Z. The role of college students is not only to increase their capacity but as geography educators can become agents in spreading UHI literacy to the community and next generation.

CONCLUSION

UHI phenomena have occurred around the world, including in Indonesia. As one of the impacts of climate change, the UHI phenomenon occurs in the urban area. The results showed that the UHI literacy of prospective geography educators

(geography education students of UMS) was high. The high level of UHI among geography education students of UMS is suspected to have an influence on the vision and mission and the geography education curriculum, one of which is about disaster mitigation. However, this research must be continued by examining the variables that affect the level of UHI literacy of UMS geography education students. Hopefully, UHI literacy is one of the non-structural mitigation activities that can mitigate UHI phenomena and maintain a sustainable environment.

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