Journal of Environment and Sustainability Education
1 (2), 2023, 80-88
Available at: joease.id/index.php/joease
ISSN 3025-0714 (online)

Climate-change literacy of first year prospective physics teacher about long dry season phenomenon in Indonesia

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Received: 10 November 2023; Revised: 22 December 2023; Accepted: 31 December 2023

Abstract: Indonesia has characteristics of increasing temperatures that have yet to be widely known. Sudden temperature changes have brought many losses to Indonesians. The study was intended to analyze the level of scientific literacy on the climate-change material for prospective physics teachers in Indonesia. The study employs a qualitative methodology. The study also utilized descriptive analysis techniques by administering surveys to gather participant data. This study uses descriptive analysis techniques through the administration of surveys to collect data from participants. Increased emissions of greenhouse gases are a contributing factor to changes in temperature and climate. The escalation of greenhouse gas emissions in Indonesia leads to climate change as these gases envelop the Earth and trap the sun's heat, intensifying the greenhouse effect. The outcome entails elevated mean temperatures, alterations in precipitation patterns, and occurrences of severe weather events such as floods and droughts. Evaluating climate or temperature changes necessitates education. Education imparts knowledge about the significance of safeguarding the planet to maintain its well-being. Education plays a crucial role in addressing the challenge of climate change, particularly the Sustainable Development Goals (SDGs).
Keywords: temperatures, climate change, SDGs

How to Cite: Deta, U. A., Arisanti, A., Laila, L., Sasmi, R. R., Lestari, N. A., Saregar, A., & Mubarok, H. (2023). Climate-change literacy of first year prospective physics teacher about long dry season phenomenon in Indonesia. *Journal of Environment and Sustainability Education*, *1*(2), 80-88. Retrieved from https://joease.id/index.php/joease/article/view/18

Introduction

Climate change pertains to enduring alterations in temperature and weather patterns. While this shift may occur naturally, human activity has significantly accelerated climate change since the 1800s, mainly through the combustion of fossil fuels (such as coal, oil, and gas), which emits greenhouse gases that trap heat. The attributes of climate change are delineated by the patterns of precipitation in Indonesia, which can be precisely examined using climate data from meteorological stations (Tanaka & Yamanaka, 1985; Yamanaka, 2016). However, spatial analysis determines it mainly by the density of precipitation networks. Virtually all terrestrial regions have recently undergone an increase in the frequency of hot days and heat waves. 2020 ranked among the warmest years ever documented. Elevated temperatures can amplify the occurrence of heat-related ailments and impede individuals' ability to engage in work and physical activity. Forest fires are more prone to ignition and rapid propagation under hotter conditions (Rajendra et al., 2014). Indonesia is a distinctive tropical area

where the behavior of the atmosphere is shaped by trade winds, monsoonal wind patterns, maritime climate, and the impact of diverse local factors (Ahmed, 2015). The weather and climate in Indonesia have unique characteristics whose formation mechanisms have yet to be widely known. Climate can be defined as a statistical measure of weather for a certain period, and weather states the status of the atmosphere at any given time.

Global warming refers to the rise in the average temperature of the Earth's surface caused by the release of significant quantities of greenhouse gases, which trap solar energy in the atmosphere. Global warming has led to detrimental consequences such as deforestation and disruption of various ecosystems, as well as rising sea levels that threaten island nations. Additionally, it has caused unfavorable changes in the Earth's climate. Greenhouse gases are atmospheric gases that can obstruct solar radiation reflected by the Earth, increasing surface temperatures (Newby, 2007). Greenhouse gases are made up of carbon oxygenated (CO2), methane (CH4), nitrous mono oxide (N2O), hydrofluorocarbon (HFCS), hexafluoride sulfur (SF6), carbon perfluoro (PFCS), and other traces of gases. Carbon dioxide and methane are the primary substances responsible for the greenhouse effect. The phenomenon resulting from greenhouse gases' impact is called the greenhouse effect. Typically, the greenhouse effect has a beneficial impact on the Earth's temperature. The greenhouse effect of methane (21 GWP) is more substantial than carbon dioxide (1 GWP).

The temperature on Earth is rising due to global warming, causing climate change on Earth (Samidjo & Suharso, 2017). Climate change impacts the environment, human health, plant productivity, and even the extinction of life populations worldwide (Meilinda et al., 2017). Formal education regarding climate change requires extensive knowledge, teacher cooperation, and good coordination during the educational process (Miléř et al., 2012). The rate of CH4 emissions into the atmosphere is the fastest among the six greenhouse gases. CH4 concentrations increased by 150% from concentrations before the Industrial Revolution in 1750 (IPCC, 2001). Climate variability and change as a result of global warming. Climate change impacts increasing the frequency and intensity of extreme weather events, changes in rain patterns, and increasing temperatures and sea levels (Surmaini et al., 2011).

This climate change is due to the increasing greenhouse gases spawned by industries. This increase in greenhouse gases accelerates the global warming process and increases the frequency of extreme weather events. Various atmospheric parameter data such as temperature, rainfall, pressure, humidity, ozone, air pollution, and others require a tool to be further analyzed.

Climate change and extreme weather cause various problems, including health problems due to disease outbreaks, fishermen who do not dare to go to sea due to high waves, farmers who fail to harvest, and other social insecurities. In connection with problems in the agricultural sector (food security) that hit parts of the world, rice production is a crop that is vulnerable to extreme events such as El-Niño and La-Niña (Cavazos, 2000; Sipayung et al., 2007; William et al. Thomson, 2016). During El-Niño, sea surface temperatures in the Pacific Ocean become warm and cause a dry and prolonged dry season in Indonesia. As a result, rice fields dry out, and rice production decreases. The existence of problems arising from climate change has become an urgency for learning related to global warming, which must be implemented in education. The education action plan in global action, namely through the SDGs, positively impacts climate change in Indonesia.

Education is the key to achieving Sustainable Development Goals (SDGs) (Machado & Davim, 2022). SDGs are global action plans formed by world leaders, including Indonesia. SDGs contain 17 Goals and 169 Targets, which are targeted to be achieved by 2030 (Habibi & Pratama, 2021). SDGs can be defined as an effort to ensure that the development efforts undertaken meet the needs of the present and do not reduce or eliminate opportunities for the next generation (Hafizah Ghany, 2018). Indonesia needs to adapt to the development of the SDGs in which the government needs to pay attention to goals that are still neglected as well as to the essential orientations of long-term development missions where long-term development is the target (Perbadi, 2017). Among other things, the goals of the SDGs are regarding handling climate change, which is a great hope for restoring the world climate from the negative impacts of not adhering to environmental ethics and understanding sustainability, which significantly influences global climate problems (Leontinus, 2022). Learning that

discusses SDGs requires education to develop a society with knowledge, abilities, and skills. In this case, the STEM (Science et al.) approach is an approach that can be used to prepare the young generation to answer the challenges they will face in society (Nguyen et al., 2020). The STEM approach can also fulfill one of the SDG goals, especially the 4th goal, namely Quality Education. This goal can be met if people have relevant 21st-century skills, especially STEM skills (Ardwiyanti et al., 2021). SDGs is a framework used globally to see references for how quality education must be prepared, one of which is through the curriculum (Thematic Curriculum).

The curriculum guides the nation's life, especially in education (Angga et al., 2022). In the Indonesian education system, there are always changes to the curriculum (Marisa, 2021). The problem of changing the curriculum in Indonesia always occurs in every generation (Hidayah & Yuliawati, 2021). One of the curriculum changes was the 2013 curriculum, which was changed to the Merdeka curriculum. In the 2013 curriculum, learning emphasizes developing students' attitudes, knowledge, and skills (Anggraini & Nurita, 2021). Then, the Merdeka curriculum is an idea to change education in Indonesia and develop a superior future generation (Angga et al., 2022). The Merdeka Curriculum was developed as a more flexible curriculum, focusing on essential material and developing students' soft skills, character, and competencies (Barlian et al., 2022). The Merdeka Curriculum places more emphasis on project-based learning, which is in line with the STEM approach. For education, the STEM approach plays a crucial role in the learning process (Sulaeman et al., 2022). In the Quarterly research (2022), research was conducted on STEM-EDP-based teaching materials on global warming, where global warming is included as one of the indicators in the SDGs. Applying the STEM approach and SDGs aspects to classroom learning will make learning more relevant and significant and increase students' creativity (Nugroho et al., 2022). Research in Indonesia, STEM shows promising results, and students who use STEM learning have better multi-presentation skills (Suwardi, 2021). So, STEM learning can be applied to the Merdeka curriculum and supported by adding aspects of the SDGs. Hence, This research aims to analyze the level of understanding of scientific literacy in climate change among prospective physics teachers in Indonesia.

Method

This study employs a qualitative methodology, utilizing descriptive analysis techniques through survey distribution to collect participant data. The research process comprises four main steps: 1) preparation and literature review, 2) development of research instruments, 3) distribution and collection of questionnaires, and 4) data study and analysis.

The investigation commences with a comprehensive examination of existing literature. This stage entails examining existing and pertinent research on climate-change literacy, with a specific emphasis on detecting patterns, deficiencies, and educational approaches utilized in different geographical areas. This evaluation establishes a basis for the study, guaranteeing that our approach is guided by the most up-to-date research and worldwide viewpoints on climate education.

The focal point of the study centers on the creation and application of various research tools. At first, a well-organized questionnaire is developed, with a specific focus on fundamental elements of knowledge, attitudes, and perceptions related to climate change. In order to obtain more profound understanding, the methodology also includes qualitative instruments such as open-ended inquiries, interviews, and focus group deliberations. These tools are specifically crafted to elicit comprehensive responses, facilitating a more intricate comprehension of the participants' perspectives. The questionnaires and interviews are sent to a meticulously chosen cohort of first-year aspiring physics educators from diverse educational establishments throughout Indonesia. The inclusion of a varied participant pool guarantees that the findings accurately reflect a broad spectrum of experiences and perspectives.

The concluding stage of the process is a meticulous examination of the gathered data. The quantitative data obtained from the surveys is evaluated utilizing statistical techniques to discern patterns and relationships. Qualitative data obtained from interviews and open-ended questions are analyzed using thematic analysis to identify important themes and narratives. This dual methodology

guarantees a thorough examination of both the extent and intensity of climate-change knowledge among the participants.

Results and Discussion

After conducting research by asking questions about the current climate and ten multiple choice questions to 102 Physics Education students at Surabaya State University regarding the understanding of Physics Education students at Surabaya State University regarding recent climate change in Indonesia, the data obtained are shown in Table 1.

Table 1. Results of Respondents' Answers

Question Number	Correct Answer	Wrong Answer
1	75	27
2	60	42
3	92	10
4	71	31
5	45	57
6	94	8
7	51	51
8	81	21
9	98	4
10	88	14

Students' understanding of climate change needs to be increased. The lack of student literacy regarding climate and temperature changes that have occurred recently is also just knowing the average student needs to look for what causes climate change. The student perspective about the temperature in Surabaya can be seen in Figure 1.

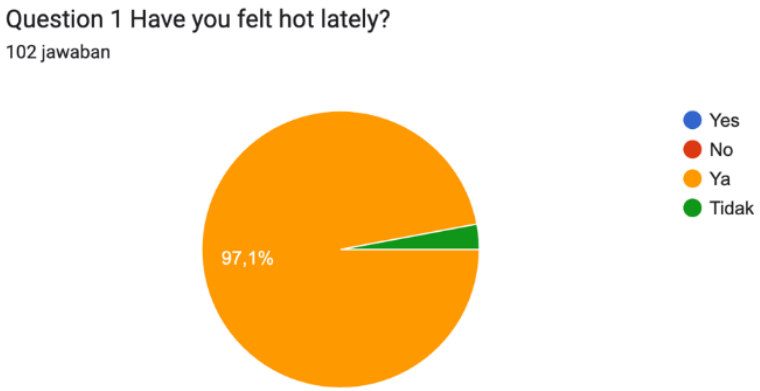

Figure 1. Regarding heat in 2023

From Figure 1, respondents feel hot; this has various reasons, including the hot temperature has increased compared to the previous hot temperature, and high air temperature and high humidity can trigger rapid sweating. And this comes from the fact that the temperature has risen slightly higher than before, up to 39°C - 40°C. The temperature outside is very high, especially when you go out without wearing a jacket, and your skin is directly exposed to sunlight. It feels like it's burning, which happens not only during the day and night, but the temperature is still above 32 °C.

Respondents knew the cause of the recent increase in temperature; 74.5% of respondents argued that the rise in temperature was due to the felling of trees, burning of land (rice fields), careless burning of rubbish, and vehicle and factory pollution. This is a factor in increasing greenhouse gas emissions and has recently impacted temperatures in Indonesia. Increased greenhouse gas emissions cause climate change in Indonesia because these gases cover the earth and trap the sun's heat,

increasing the intensity of the greenhouse effect. This results in increased average temperatures, changes in rainfall patterns, and extreme weather events such as floods and droughts. Reducing greenhouse gas emissions is essential to reduce the negative impacts of climate change. Increased greenhouse gas emissions cause an increase in the concentration of gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) in the atmosphere. These gases act like a blanket that traps the sun's heat in the Earth's atmosphere, thereby causing an increase in global temperatures. This can cause climate change, including changes in weather patterns, increases in average temperatures, increases in sea levels, and changes in ecosystems. In Indonesia, increasing greenhouse gas emissions can also impact climate change, such as rising temperatures, rainfall, and the risk of natural disasters.

From the questionnaire that has been carried out, it can be seen that extreme weather has recently disrupted activities. According to respondents, this is because hot temperatures can affect the brain and mood. The body becomes tired quickly because it is forced to work harder to maintain optimal temperature, which makes you lazy or makes you want not to leave the house. This increase in global temperature can cause extreme weather and climate patterns. When the atmosphere holds more water vapor, this can lead to increased rainfall and more intense storms. In addition, global warming can also cause an increase in droughts and extreme heat waves. Global warming causes an increase in the temperature of the earth's surface, which in turn causes greater evaporation of water from sea and land surfaces. This increases the water vapor content in the atmosphere. Because water vapor is a greenhouse gas, increasing its amount can strengthen the greenhouse effect, causing higher global temperatures. Additionally, when water vapor condenses, it can cause more intense rainfall and other extreme weather phenomena, creating more extreme climate conditions. So when the temperature increases drastically, activities are disrupted. And 92.2% of students are reluctant to do activities outside the home due to rising temperatures. According to respondents, extreme weather had occurred in the previous year. In 2021 – 2023 the temperature was hotter than the previous year, but respondents felt that this year felt very hot and was the most extreme or hottest weather on record.

Of respondents to question one, 73.5% answered correctly, that the cause of recent increases in temperature in Indonesia is due to an increase in greenhouse gas emissions, air movement in the atmosphere, and changes in atmospheric conditions. Changes in soil conditions do not directly affect air temperature in the area. The main cause of rising temperatures is increased greenhouse gas emissions, which can cause global warming effects. Air movement in the atmosphere and changes in atmospheric conditions can also affect air temperature, but are not directly related to soil conditions.

Respondents argued that the greenhouse effect that contributes to climate change is the containment of heat radiation by certain gases in the atmosphere, which causes global warming and a natural phenomenon where certain gases in the earth's atmosphere restrain heat radiation from the earth's surface. These gases, such as carbon dioxide (CO2), methane (CH4), and nitrogen oxide (N2O), have the ability to absorb and re-emit infrared radiation, which is the heat emitted by the earth's surface after being exposed to sunlight. The greenhouse effect contributes to climate change by causing changes in average temperatures around the world. Rising global temperatures can affect weather and climate patterns, including changes in rainfall patterns, increases in extreme weather events, and changes in wind patterns. This can have an impact on ecosystems, agriculture, water availability and human life as a whole.

This global warming is an incident of trapping of the sun's long wave radiation (heat waves or infrared) emitted to the Earth by greenhouse gases, and 69.6% answered correctly regarding understanding global warming. An increase in the average temperature on the Earth's surface and atmosphere occurs due to the rise in the concentration of greenhouse gases in the atmosphere, which can absorb and re-emit long-wave solar radiation (heat waves or infrared). Sunlight that reaches the Earth's surface is mainly absorbed by soil, water, and vegetation. A small portion of this energy is reflected into the atmosphere as long-wave radiation. Greenhouse gases in the atmosphere absorb this radiation and radiate it back to the Earth's surface, trapping heat in the atmosphere and preventing it from escaping into space. As a result, the temperature on the Earth's surface increases, known as global warming.

Global warming has many causes, including environmental conditions where most people use transportation, pile up piles of rubbish, relatively large amounts of carbon dioxide, deforestation, and motor vehicle pollution. The use of transportation by the majority of people in environmental conditions does not directly cause global warming. Although motor vehicle use can produce greenhouse gas emissions, such as carbon dioxide, contributing to global warming, this factor has more to do with air pollution than overall environmental conditions—ever-accumulating piles of rubbish, deforestation, and greenhouse gas emissions such as carbon dioxide cause global warming. However, respondents had misconceptions about this question because answer options needed clarification, namely the presence of carbon dioxide, quite large greenhouse gases, and reforestation. This question has a negative meaning or is not a cause. As many as 36.3% of respondents answered that piles of rubbish were piling up. Piles of rubbish can cause global warming, so respondents lacked concentration and literacy in this question.

The relationship between global warming and weather and temperature is that global warming causes sea surface temperatures to become cooler because most of the heat trapped in the earth's atmosphere is absorbed by the ocean. Respondents argued that global warming causes climate change with several impacts, including rising sea levels due to melting ice and thermal expansion of warmer sea water. Apart from that, global warming also contributes to changes in weather patterns by increasing the intensity of extreme weather phenomena such as storms, floods and droughts. All of these changes affect regional temperatures, rainfall, and overall weather patterns. When global warming occurs, climate conditions can become extreme because global warming causes the atmosphere to hold more water vapor as a result of warming on the earth's surface. Global warming causes the atmosphere to have more water vapor due to warming the earth's surface. As global temperatures rise, the oceans evaporate more water, which then increases humidity in the atmosphere. This can trigger changes in rain patterns, storm strength and extreme weather events due to increased thermal energy in the atmosphere which supports more intense weather phenomena.

Climate change in Indonesia recently has had several impacts, including damage to ecosystems, decreased water quality, many health problems, damage to infrastructure, increased frequency and intensity of natural disasters and the extinction of certain species. From this question, 79.4% of respondents answered correctly and had various reasons, including that the large amount of water available and its good quality is not the impact of climate change, but rather factors related to hydrological conditions and the availability of water resources. The impacts of climate change that generally occur in Indonesia involve problems such as increasing the frequency and intensity of natural disasters, damage to ecosystems, decreased water quality, and the extinction of certain species. Thus, option B, "A lot of water is available and the quality is good," is not a direct impact of climate change in Indonesia. The impacts of climate change occurring in Indonesia include damage to ecosystems, decreased water quality, extinction of certain species, increased frequency and intensity of natural disasters, as well as many health problems and damage to infrastructure. However, the amount of water available and its good quality is not a direct impact of climate change. Climate change is likely to cause uncertainty in rainfall patterns, resulting in droughts or floods in some areas. Although there are regional variations in these impacts, in general, climate change tends to disrupt natural water cycles, which can result in instability in water supplies, both in terms of quantity and quality. However, there is no guarantee that water will remain abundant and of good quality as a direct result of climate change.

Climate or temperature changes require evaluation, one of which is education. Education can provide lessons regarding the importance of protecting the earth to keep it healthy. One of the roles of education in responding to the challenge of climate change is with the SDGs. The role of higher education in achieving the SDGs and responding to the challenge of climate change is to provide a curriculum that includes sustainability and climate change solutions. 96.1% of respondents knew about the role of education in responding to the challenge of climate change, namely the SDGs. According to respondents, higher education has an essential role in achieving Sustainable Development Goals (SDGs) and responding to the challenges of climate change. By providing a curriculum that includes sustainability and climate change solutions, universities can prepare future generations to become environmentally conscious leaders committed to addressing environmental problems. Universities can

provide in-depth knowledge and understanding of environmental issues and how to deal with them through a curriculum that includes sustainability and climate change solutions. This may include environmental science, renewable energy, natural resource management, and environmental policy. In addition, higher education can also play an essential role in conducting research and innovation to develop sustainable solutions to climate change. Through research and development, universities can contribute to producing environmentally friendly technology and practices and provide a better understanding of the impacts of climate change and how to overcome them. Increasing education costs is not directly related to the role of higher education in achieving the SDGs and responding to the challenge of climate change. Reducing the focus on environmental research is also inappropriate, as environmental research is essential in developing climate change solutions. Giving priority to business programs is also irrelevant because climate change is an issue that involves various scientific disciplines and is not only related to business.

The benefit of including global dimensions and international cooperation in education related to climate change is to foster an understanding of global challenges and their solutions. Incorporating global dimensions and international cooperation in climate change education has significant benefits. This will help students understand the global challenges faced by climate change, develop collaboration and communication skills, and open access to critical international resources. In addition, including international cooperation in education can help students understand the importance of working with other countries to address climate change. Countries can share knowledge, technology, and resources through international collaboration to reduce greenhouse gas emissions and develop sustainable solutions. Thus, including a global dimension and international cooperation in climate change education can help foster a better understanding of the global challenges faced by climate change and the solutions needed to meet them.

Providing SDGs learning means that the teaching in the classroom is in line with sustainable development goals (Pradhan et al. 2017). Learning that includes sustainable education can make students more creative, active, and concerned about the environment to overcome global problems and climate change (Jauhariyah. M. N. R, 2019). Therefore, educational innovations related to the environment can be taught based on activities outside the classroom. Students are more active in protecting the environment in learning that integrates climate action in the SDGs than conventional learning. This explains that implementing SDGs-based learning can make UNESCO programs successful, especially in education. Sustainable education means providing ideas accompanied by direct action to protect the environment. The importance of protecting the environment and the sustainability goals of the SDGs offer the benefit of greater awareness of protecting the environment, especially the earth, so that it lasts longer. Therefore, there is a need for breakthroughs in developing the integration of SDGs goals with other relevant physics materials that can emerge soon to achieve more SDGs goals.

Conclusion

Indonesia will experience very extreme climate change in 2023. This climate change has many causes, including increasing greenhouse gas emissions. Increased greenhouse gas emissions cause climate change in Indonesia because these gases cover the earth and trap the sun's heat, increasing the intensity of the greenhouse effect. This results in increased average temperatures, changes in rainfall patterns, and extreme weather events such as floods and droughts. Climate or temperature changes require evaluation, one of which is education. Education can provide lessons regarding the importance of protecting the earth to keep it healthy. One of the roles of education in responding to the challenge of climate change is with the SDGs. SDGs-based learning can make UNESCO programs a success, especially in the field of education. Sustainable education means providing ideas accompanied by direct action to protect the environment.

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