

Middle School Students Perceptions of the Greenhouse Effect, Global Warming, and Climate Change*

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Abstract

The greenhouse effect, global warming, and climate change are undoubtedly the biggest environmental problems of our age. It is important to examine the students' perspectives and perceptions towards these important environmental problems in depth. The aim of the study was to examine the perceptions of middle school students about the greenhouse effect, global warming, and climate change. A total of 31, 8th-grade students selected by convenience sampling method participated in this study. The phenomenology model, one of the qualitative research designs, was used in the research. The data was collected through semi-structured interviews. The students have perceived that the climates change due to various environmental events and the change of seasons. In addition, they put forward the causes of the greenhouse effect and global warming and various measures that can be taken against them.

Keywords: Climate Change, Global Warming, Greenhouse Effect, Middle School Students

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INTRODUCTION

Climate change is a growing global problem that threatens development and environmental sustainability in the 21st century (Kibe, 2018). United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as “a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods”. Climate change refers to a long-term change in the regional or global climate pattern. This phenomenon is attributed to human activities that cause an increase in the concentration of greenhouse gases in the global atmosphere. Climate change has major impacts on the physical environment, biota, and water (Zareian et al., 2017).

Environmental problems, such as the increase in global warming due to the aggravation of the "greenhouse effect" caused by atmospheric pollution, are becoming more and more important. Therefore, education in such matters is increasingly becoming more significant (Boyes & Stanisstreet, 1993). UNFCCC also defines greenhouse gases as “the gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation”.

In recent years, extreme climate change and atmospheric events have become global problems. Global warming and climate change are caused mainly by three gases: carbon dioxide (CO₂), methane (CH₄), and dinitrous oxide (N₂O). In addition to these gases, chlorofluorocarbon, which has been widely used in industry in the past, has also contributed significantly to global warming. Naturally produced gases have no harmful effects; on the contrary, their presence in the atmosphere within normal limits contributes to the prevention of some heat loss from the Earth and the formation of atmospheric conditions that ensure the continuity of life on Earth. It is also known that livestock production contributes to global warming to some extent. Climate change has direct and indirect effects on animals (Koluman et al., 2018).

The global scientific community is almost in agreement that anthropogenic emission of greenhouse gases, and thus increased atmospheric concentration, is causing global warming and other climate changes. Due to the increase in temperature, drought, forest fires, typhoons, severe hurricanes, frequent storms, and decline in air quality, future human health problems will be catastrophic. Considering the current climate trend, climate scientists predict that new ecosystems will emerge and disappear in the future, and this change in biomes will be irreversible. Not only ecosystem destruction but also climate migration is currently a major problem. People's ignorance, greed, not holding themselves responsible for climate change, and seeing it as a global effect sometimes led them to violate natural/environmental rules and these activities have obvious results (Chatterjee & Tandon, 2020).

As climate change education programs grow and build on each other, they can play an important role in developing the communities of practical visionaries necessary to tackle future challenges (Monroe et al., 2019). Climate knowledge assists in developing appropriate farming strategies and managing crops. Evidence over the past few decades shows that significant changes in climate have occurred around the world as a result of increased human activities through deforestation, the release of various greenhouse gases, and the indiscriminate use of fossil fuels (Kesava Rao et al., 2020). It is vital that both present and future generations are better equipped to tackle the problem of climate change. This can be achieved through the adoption of appropriate pedagogical methods aimed at helping students develop their understanding of climate change science and acquire the skills necessary to mitigate its impact. Learning is more effective when students are challenged to identify the cause and effect of a problem they can relate to in their lives. Thus, climate change is a problem that needs to be addressed and can be adopted for more effective teaching (Chopra et al., 2019). Therefore, education in such matters is becoming more and more important. Educational strategies and resources should best be designed based on an assessment of children's prejudices and children's ideas in this area should be evaluated (Boyes & Stanisstreet, 1993). Consequently, the current study aimed to examine the perceptions of middle school students about the greenhouse effect, global warming, and climate change. The related research questions were as follows:

- How do students perceive climate change?
 - What are the causes of climate change?
 - What are the consequences of climate change?
 - What should be done to prevent climate change?
- How do students perceive the concept of the greenhouse effect?
 - What are the causes of the greenhouse effect?
 - What are the consequences of the greenhouse effect?
- How do students perceive the concept of global warming?
 - What are the consequences of global warming?
 - What should be done to prevent global warming?
 - How can awareness be raised against global warming?

METHODOLOGY

The phenomenology model, one of the qualitative research designs, was used in the research.

Study Group

The study group consists of 31, 8th-grade students studying in eight secondary schools in a city in the Marmara region. A convenience sampling method was adopted in this study.

Data Collection Tools

A semi-structured interview form was used as a data collection tool. Interview questions prepared by the researchers of the study considering the science course curriculum, the 8th-grade science textbook, and the studies in the related literature consist of 11 open-ended questions and some probing questions to determine the views of secondary school 8th-grade students about global warming and climate change.

Data Analysis

Interview questions were presented to field experts twice before the data collection process. After the necessary improvements of the questions in line with the expert opinions, the ethics committee and data collection permissions of the study were obtained, respectively. The related data were collected by the researcher through a face-to-face semi-structured interview form. After the interviews were transcribed, the data were evaluated with the descriptive content analysis method.

RESULTS

In this section, the qualitative analysis of the semi-structured interviews with 8th-grade students about global warming and climate change is given.

Are the climates changing?

8th-grade students were asked whether climates have changed, and those who thought that climates have changed were asked to explain why and describe climate change in their own words. Students' views on climate change are given in Table 1.

Table 1

Causes of Climate Change

Causes of climate change	f
Change of seasons	14
Global warming	11
Greenhouse gases/effect	9
Harmful/toxic gases	9
Deodorants	4
Fossil fuels	4
Unsuitable temperature for the season	3
Industry/factories	3
Human consumption	2
Deforestation	2

All the interviewed students agreed that climates have changed. As seen in Table 1, most of the students ($n=14$) who participated in the interview cited the change of seasons as the reason for climate change. Students consider global warming ($n=11$), greenhouse gases/effect ($n=9$), harmful/toxic gases ($n=9$), deodorants ($n=4$), fossil fuels ($n=4$), unsuitable temperature for the season ($n=3$), industry/factories ($n=3$), human consumption ($n=2$) and deforestation ($n=2$) as the causes of climate change. In addition, students were asked to describe climate change in their own words. Some examples of students' definitions of climate change are presented below:

“Climate change can be defined as nature's punishment to humans as a result of human insensitivity.”

“Climate change is the increase in temperature, the slow change of the climate experienced in that region over time.”

“Climate change is the result of the activities of people, that is, the activities of living things and the seasons and climates in the world are out of normal.”

“I define it as the occurrence of climates later or earlier in their history.”

“The variation of the average of weather events over many years”.

The students were asked what some experts claim that the temperature of the Earth is increasing and what they think about this issue. Below are some of the students' views on this subject:

"I agree. In other words, as I just said, the gases emitted from human use cause the greenhouse effect. The greenhouse effect also increases temperatures. I think everybody knows that.”

"I think yes. Because it gets warmer, we see it mostly at the poles. With the melting of the poles, they say yes, it is true.”

"Yes, I think it's true because for some reason every year we see more temperature rises even in different seasons like this because of global warming.”

“I find that true too. The temperature is increasing. As a result of people's unconscious use of natural resources, in other words, because they use fossil fuels too much, the temperature is increasing.”

“I think so too because the poles can be the best example of that. When I see a picture comparing 1990 and 2022, when everything was ice in 1990, in 2022, there is nothing left in the name of ice, polar bears are trying to migrate, which I think is one of the clearest indicators of the increase in temperature.”

“Yes, the temperature of our world is increasing. The ozone layer is being perforated and the rays from the sun hit the earth.”

"Yes. As can be seen in many articles, the temperature of the world has increased by 1-1.5 degrees in the last 100 years. This is something very visible. In other words, the seasons are much warmer than the previous years. The biggest reason for this is the greenhouse effect.”

"I agree. I think the temperature of our world is increasing due to climate change. This can cause huge problems in the future.”

The consequences of climate change and the future of the world

Students were asked what the consequences of climate change are and whether they think that climate change has an impact on the future of the world. Students' views on the consequences of climate change are given in Table 2.

Table 2

Consequences of Climate Change

Consequences of climate change	f
Melting glaciers	14
Decrease/depletion of plant and animal diversity	12
Drought	10
Change in annual average temperatures	10
Sea level rise	5
Flood	5
Agricultural problems	5
Forest fires	4
Change of seasons	4
Air pollution	4
Change in weather events	4
Severe natural disasters	2
Pollution of water	1
Epidemic diseases	1
Hunger/poverty	1

Students cited the melting of glaciers because of climate change ($n=14$) as an example. This is followed by the decrease/depletion of plant and animal diversity ($n=12$), drought ($n=10$), change in annual average temperatures ($n=10$), increase in sea level ($n=5$), flood ($n=5$), agricultural problems ($n=5$), forest fires ($n=4$), change of seasons ($n=4$), air pollution ($n=4$), change in weather events ($n=4$), severe natural disasters ($n=2$), water pollution ($n=1$), epidemic diseases ($n=1$), and hunger/poverty ($n=1$) (Table 2). In addition, students were asked to explain whether they thought that climate change would affect the future of the world and why. Some students' views on how climate change would affect the future of the world are presented below:

“...the climate is what allows humans to live on Earth anyway. If there is no climate where we can live properly, for example, if there is an average temperature of 50 degrees, people cannot live. I think it is vital for both human life and living life.”

“I think because if the world were flooded, the world would be uninhabitable. That's why people can't live at work.”

“Of course, I think because there are also soil crops. Agricultural crops may suffer as the climate changes frequently. So, our food stocks may be running low...”

“...because climate change is affecting people's lives to a great extent. Like natural disasters, I just said. Here, the rise in water level, fires, and so on will increase the death of people. So, the population is going down, so it's very likely.”

“Yes, I think it will. In the future, there will be water scarcity, flood disasters, and so on. I think that if there are sudden changes, the loss of crops will increase, and in this way, people will face the danger of starvation.”

"Yes. As climates change, people may have trouble keeping up. That's why we may experience various problems... As the climate changes, animals living in different parts of the world may lose their natural habitats and environments and become extinct.”

"Yes, I think. Because at this rate, if our lands continue to be damaged, the trees will disappear. With the disappearance of trees, oxygen production will almost stop.”

“I think because our world is running out of water resources. In other words, animals are going extinct, I think humanity has started to go extinct, I mean, after what we saw. So, I personally think it will affect it more in the future.”

Interviews with students indicated that because of climate change, people and other living things will struggle with increasing temperatures, floods, drought, famine, fires, natural disasters, and air pollution, and thus the future of the Earth will be deeply affected.

Climate change measures

Students were asked what should be done to prevent climate change. Students' views on climate change measures are given in Table 3.

Table 3

Climate Change Measures

Climate change measures	f
Installing filters of factory chimneys	16
Reducing greenhouse/toxic/harmful gas emissions	11
Reducing deodorant usage	9
Public transport choice	9
Increasing environmental awareness	9
Renewable energy sources choice	9
Reducing the use of fossil fuels	8
Afforestation	5
Energy savings	5
Using electrical vehicles	4
Giving importance to recycling	4
Saving water	3
Stop disproportionate reproduction	1

In order to prevent climate change, students recommended installing filters on factory chimneys ($n=16$), reducing greenhouse/toxic/harmful gas emissions ($n=11$), reducing deodorant usage ($n=9$), public transport choice ($n=9$), increasing environmental awareness ($n=9$), renewable energy sources choice ($n=9$), reducing the use of fossil fuels ($n=8$), afforestation ($n=5$), energy savings ($n=5$), using electrical vehicles ($n=4$), giving importance to recycling ($n=4$), saving water ($n=3$) and stop disproportionate reproduction ($n=1$) (Table 3).

Causes and consequences of the greenhouse effect

The students were asked what the concept of the greenhouse effect meant to them, and what were the causes and consequences of the greenhouse effect. Students' views regarding the causes and consequences of the greenhouse effect are given in Table 4.

Table 4

Greenhouse Effect

Causes of greenhouse effect	f	Consequences of greenhouse effect	f
Factory gases	14	Melting glaciers	12
Vehicles/exhaust gas	12	Death of living things/respiratory diseases	12
Deodorants/perfumes	9	Extinction of living things	11
Harmful/toxic gases	9	Change of seasons/climates	8
Fossil fuels	8	Air pollution	7
Cutting down trees/deforestation	6	Environmental pollution/change	7
Humans/unconscious consumption	6	Temperature rise	6
Pollution of the seas	3	Drought/desertification	6
Environmental pollution	3	Global warming	6
Global warming	2	Sea level rise	5
Air pollution	2	Reduction of animal habitats	4
Pesticides	1	Flood	3
Depletion of the ozone layer	1	Landslide/erosion	3
		Forest fires	2
		Hurricanes	2
		Depletion of potable water resources	2
		Food shortage	1
		Mutations	1
		Ozone depletion	1
		Acid rains	1

The students thought that the biggest causes of the greenhouse effect were factory gases ($n=14$) and vehicles/exhaust gases ($n=12$). In addition, they stated that deodorants/perfumes ($n=9$),

harmful/toxic gases ($n=9$), fossil fuels ($n=8$), cutting down trees/deforestation ($n=6$), humans/unconscious consumption ($n=6$), pollution of seas ($n=3$), environmental pollution ($n=3$), global warming ($n=2$), air pollution ($n=2$), pesticides ($n=1$), ozone layer depletion ($n=1$) were also other causes of the greenhouse effect (Table 4).

The students stated that the biggest consequences of the greenhouse effect are the melting of glaciers ($n=12$), the death of living things/respiratory diseases ($n=12$), and the extinction of living things ($n=11$). These results are respectively followed by the change of seasons/climates ($n=8$), air pollution ($n=7$), environmental pollution/change ($n=7$), temperature rise ($n=6$), drought/desertification ($n=6$), global warming ($n=6$), sea level rise ($n=5$), reduction of animal habitats ($n=4$), flood ($n=3$), landslide/erosion ($n=3$), forest fires ($n=2$), hurricanes ($n=2$), depletion of potable water resources ($n=2$), food shortages ($n=1$), mutations ($n=1$), ozone depletion ($n=1$), and acid rains ($n=1$) (Table 4). Students were asked to describe the greenhouse effect in their own words. Some of the students' definitions of the greenhouse effect are given below:

“An effect created by the combination of harmful gases in the atmosphere.”

“When I think of the greenhouse effect, for some reason, factory chimneys always come to mind. Like the pollution of the environment, the perforation of the atmosphere.”

“The capture of the rays from the Sun by the gases on Earth has a greenhouse effect.”

“For me, air pollution means air pollution because there will be a lot of carbon dioxide. This is negative for people, that is for us.”

“The harmful gases emitted by humans accumulate in the atmosphere of the world and trap the sun's rays, thus warming the world and thus disrupting the balance.”

“The greenhouse effect is that the rays from the sun pierce the ozone layer, increase in carbon dioxide, increase in ozone gases.”

“The greenhouse effect is the inability of the sun's rays to come out to the world.”

“Some of the sun's rays go back to space from the atmosphere, so greenhouse gases are the gases that prevent this. The greenhouse effect is exactly that.”

“The greenhouse effect is the trapping of harmful gases by those rays in the atmosphere.”

“The greenhouse effect occurs as a result of the change of the air in the atmosphere of the earth, the gases in the air.”

“The greenhouse effect is the inability of the rays from the sun to come to earth and return to space.”

“It seems to me like the temperature on Earth is increasing.”

“The concept of the greenhouse effect, for me, is a harmful gas. It might have something to do with acid rain or something.”

“Greenhouse effect polluted air.”

“It prevents harmful gases from entering the earth by piercing the ozone layer, and then leaving the earth by forming a cloud of gas.”

“Bad gases released into the air.”

“Harmful gas for me. Carbon dioxide, that is, methane gases, gases coming out of these factories, harmful gases.”

"The sun's rays are trapped by the carbon dioxide inside and the world is warming faster."

Interviews with the students indicated that they also expressed the effect of harmful gases regarding the greenhouse effect, the accumulation of harmful gases in the atmosphere and the trapping of the sun's rays by these gases, and the increase in Earth temperature due to polluted air and harmful gases.

Global warming

The students were asked whether they had heard of the concept of global warming, and they were asked to explain this concept. Some of the students' definitions of global warming are presented below:

“Global warming was the fact that sunlight was trapped in the Earth due to greenhouse gases, I guess I don't remember exactly right now, but because of these trapped rays, the greenhouse gases in the world hold the rays, while they should normally be reflected in the atmosphere, I guess that's why there are temperature increases. As I just mentioned, things like temperature increase, drought, and melting of glaciers are happening.”

“The drying of the trees, the retreat of the seas, and so on. I mean, teacher, that's a bad thing, right, yes, it is.”

“I've heard of the concept of global warming, so I hear it everywhere. We cause the greenhouse effect because our plants cannot photosynthesize or because we do not plant plants, so photosynthesis is very low and carbon dioxide is too high compared to oxygen. The greenhouse effect also increases global warming. As a result of global warming, issues such as climate changes that I just mentioned are increasing more.”

“Global warming occurs when temperatures increase on Earth as a result of the greenhouse effect.”

“Global warming is the increase in the temperature of the world with the effect of greenhouse gas. So, a lot of greenhouse gas emissions can be an example of this again, or people acting unconsciously.”

“Excessive use of harmful gases is depleting the ozone layer, which is why global warming occurs.”

“As a result of humans, for example, while driving, the increase in the temperature of the earth's surface by rising the gases from the exhaust is called global warming.”

“Global warming is caused by the gases emitted by humans causing the world to warm.”

“I think global warming is climate change with the increase of harmful gases in the atmosphere and negative things in the environment.”

“As a result of the greenhouse effect, which is thought to be caused by harmful gases released into the atmosphere, the increase in the average temperature measured in land, sea, and air throughout the year in the world.”

“Global warming may be something that occurs when gases like carbon dioxide increase in the atmosphere.”

“The main reason for global warming is the greenhouse gases released into the atmosphere causing global warming.”

“I have heard of the concept of global warming. Global warming is a change in the temperature of our world, an increase in its temperature. Global warming can endanger the extinction of living things.”

“Global warming is the fact that some of the sun's rays affect the earth excessively, causing it to overheat.”

“Global warming is an effect caused by the pollution of the atmosphere with the greenhouse effect. It is a pollution created by the release of carbon dioxide or gases like it to the world.”

“Global warming is something that occurs when heat-trapping gases such as carbon dioxide increase in the atmosphere. In other words, it may also occur with an increase in average temperatures measured on land, sea, and air.”

"Global warming, the badly polluted air on the earth goes into the atmosphere, the layer becomes thicker, and the rays cannot reach the earth."

“I have heard of the concept of global warming. Global warming is the increasing temperature of the earth.”

“Global warming is the penetration of the sun's rays through the ozone layer by piercing the ozone layer of greenhouse gases. Then it forms a gas cloud, preventing the rays from escaping. And the world is warming up like this, it can't get cold again, so it can't get too cold.”

“The bad gases released into the air are the rise in temperature due to the greenhouse gases released by the combustion of fossil fuels.”

“I have heard of the concept of global warming. This is something that is increasing and growing with the greenhouse gas effect, which increases the temperature of the earth. It is the same as a chain effect. It causes the glaciers to melt, and it affects animals, humans, all living things.”

“The increase in temperature due to the greenhouse effect.”

The interviews with students indicated that they heard the concept of global warming everywhere, that global warming is a bad thing, the warming of the world as a result of the greenhouse effect, the increase in the world temperature, and climate change due to the gases released as a result of human effects, the effect caused by the increase of greenhouse gases in the atmosphere, the increase in the temperature of the heat-trapping gases in the Earth.

Measures to be taken against global warming

The students were asked what precautions could be taken against global warming and whether they took individual precautions. Students' opinions about the measures they can take against global warming and the precautions they take are given in Table 5.

Table 5

Measures to be Taken Against Global Warming

Measures to be taken against global warming	f	Individual measures against global warming	f
Installing filters on factory chimneys/cars	16	Not polluting the environment/sensitivity	9
Afforestation	14	Not using deodorants	8
Using renewable energy sources	8	Transportation by cycling/walking	7
Recycling	8	Giving importance to recycling	6
Prefer public transportation/cycling	7	Planting trees	6
Reducing fossil fuel use	6	Energy-saving	5
Not using air-conditioning	5	Prefer public transportation	4
Not using deodorants	5	Water saving	3
Saving electricity	5	Using renewable energy	2
Using electric vehicles	5	Not pouring oils into the sink	2
Preventing greenhouse gas emissions	5	Not using air conditioning	1
Being sensitive to nature/environment	4	Supporting nature conservation campaigns	1
Using natural resources economically/consciously	3	Protecting forests/trees	1
Heat insulation	2	Not using fossil fuels	1
Water saving	2	Choosing electric vehicles	1
Reducing detergent use	1		
Controlled breeding	1		
Using paper instead of plastic	1		
Not spilling oil into the sea	1		
Legal obligation (Tree tax)	1		

Students suggested installing filters on factory chimneys/cars ($n=16$) and afforestation ($n=14$) as the main measures that can be taken against global warming. Using renewable energy sources ($n=8$), recycling ($n=8$), choosing public transportation/cycling ($n=7$), reducing fossil fuel use ($n=6$), not using air-conditioning ($n=5$), not using deodorants ($n=5$), saving electricity ($n=5$), using electric vehicles ($n=5$), preventing greenhouse gas emissions ($n=5$), being sensitive to nature/environment ($n=4$), using natural resources using economically/consciously ($n=3$), heat insulation ($n=2$), water saving ($n=2$), reducing detergent use ($n=1$), controlled breeding ($n=1$), using paper instead of plastic ($n=1$), not spilling oil into the sea ($n=1$) and legal obligation (tree tax) ($n=1$). Furthermore, students

mentioned that they take some individual measures against global warming such as not polluting the environment/sensitivity ($n=9$), not using deodorants ($n=8$), transportation by cycling/walking ($n=7$), giving importance to recycling ($n=6$), planting trees ($n=6$), saving energy ($n=5$), preferring public transportation ($n=4$), water saving ($n=3$), using renewable energy ($n=2$), not pouring oils into the sink ($n=2$), not using air conditioning ($n=1$), supporting nature conservation campaigns ($n=1$), protecting forests/trees ($n=1$), not using fossil fuels ($n=1$) and choosing electric vehicles ($n=1$) (Table 5).

Consequences of global warming

Students were asked what the consequences of global warming are. Students' views on the consequences of global warming are given in Table 6.

Table 6

Consequences of Global Warming

Consequences of global warming	f
Melting glaciers	22
Temperature rise	13
Sea level rise	12
Animal/human extinction	9
Drought/desertification	8
Diseases/death	6
Climate change	5
Some visible changes/pollution in the environment	5
Weather events	5
Damage to natural habitats	4
Decrease in potable water resources	4
Air pollution	3
Decrease in biodiversity	3
Food shortage	3
Forest fires	2
Mutations	2
Natural disasters	2
Depletion of fossil fuels	1
Wars	1
Perforation of the atmosphere	1
Ebb tide	1

Students gave examples of melting of glaciers ($n=22$), temperature rise ($n=13$), sea level rise ($n=12$), animal/human extinction ($n=9$), drought/desertification ($n=8$), diseases/death ($n=6$), climate change ($n=5$), some visible changes/pollution in the environment ($n=5$), weather events ($n=5$), damage

to natural habitats ($n=4$), decrease in potable water resources ($n= 4$), air pollution ($n=3$), decrease in biodiversity ($n=3$), food shortages ($n=3$), forest fires ($n=2$), mutations ($n=2$), natural disasters ($n=2$), depletion of fossil fuels ($n=1$), wars ($n=1$), perforation of the atmosphere ($n=1$) and ebb tide ($n=1$) to the consequences of global warming (Table 6).

The effects of global warming on living things

The students were asked about the effects of global warming on living things and whether it has an impact on the future of the world. Students' views on the effects of global warming on living things are given in Table 7.

Table 7

The Effects of Global Warming on Living Things

The effects of global warming on living things	f
Extinction of life	15
Diseases/death	15
Food/water scarcity	11
Habitat damage	10
Mutations	5
Disruption of the food chain	3
Fires	3
Floods	2
Whirlwind	1
Energy shortage	1
Skin damage	1

Students stated that global warming has an effect on living things such as the extinction of life ($n=15$), diseases/death ($n=15$), food/water scarcity ($n=11$), habitat damage ($n=10$), mutations ($n=5$), disruption of the food chain ($n=3$), fires ($n=3$), floods ($n=2$), whirlwind ($n=1$), energy shortage ($n=1$) and skin damage ($n=1$) (Table 7). In addition, some of the student's views on the effect of global warming on living things are presented below:

"Yes. I think that global warming has an impact on the future of the world. The world may even disappear, so it's likely if it continues like this. After all, when the world is destroyed, living things will disappear, not only humans but also animals, plants, everything."

"In general, water and agricultural products, for example, may decrease gradually, already today, quite a lot of droughts have started and this seems to increase a lot. Many animals are endangered."

"I think this way, nature will surely renew itself one day and as a result of this renewal, it will swallow us as long as we do not take care of nature. All animals, maybe us, everything will go extinct. I think that our generation will also decrease, end, and go extinct."

“I think because I have an idea that the impact on the future of the world will be something like this. As water resources decrease, water wars will begin. As the water wars start, there will be more chaos and one state will always stand by the other. However, this could lead to a major war. Ultimately it could be for animal food or living resources. Or I think there will definitely be wars for more such rich lands. I think it will over impress the future of the world. So, people are destroying their own futures with their own hands. There may be wars.”

“Yes, I think that global warming has an impact on the future of the world. Global warming causes an increase in temperature. The waters will decrease, and the waters will rise. The amount of water that people can drink will decrease, and drought will begin. There will be a decrease in the nutrition of people, the death rate will increase.”

“I think because if it goes on like this, the world will be very hot, people will not be able to live, so we may have to move to another planet in the world. Water resources will run out, that's all I can think of.”

“Of course, I think it has an impact on the future, because as we harm the environment and the world gets warmer, maybe there will be no glaciers in the future, and other diseases will arise.”

“It will have an impact on the future of the world because global warming is basically the main reason that triggers climate change. So, this will have bigger consequences, that is, even more, climate change. In fact, I can give the examples I gave about climate change. Again, in the future of the world, it may cause diseases. It can cause people to die, animals to die.”

“I think global warming is something that can put the future of the world at risk. Because it leads to the extinction of living things, climate change and may cause many more problems and endanger the future of the world.”

“Yes, I think because our forest areas are getting fewer and fewer and if it continues to decrease, the trees will disappear. If the trees are destroyed, the oxygen will run out. So, there will be no air for us to breathe here. Besides, the glaciers are already melting, so the water level will rise and there will be no land on the surface.”

“It happens because if it continues like this, the polluted air coming out of the earth will increase more and more because the number of people is increasing. There are more factories and cars, even though there are almost two cars in every house. Considering that everyone goes every day, more polluted air and greenhouse gases come out. For this reason, because the earth's atmosphere becomes thicker, the sun's rays cannot reach the earth. When the sun's rays can't come, climate change happens.”

“I think because I said that it will mutate in the future, so animals can be different, new diseases will occur, so it has already started to happen. As the water content decreases, different things will start to happen.”

“Yes, I think because the world will warm up due to global warming and there will be air pollution, people can be poisoned in the future. Since the temperature of the world will increase, the climate may change, and people may not be able to adapt. Pollution may also increase. Many animal species may perish, some most humans may die from radiation, perhaps from pollution.”

“I think because global warming causes climate change and this climate change can increase diseases due to natural disasters. Therefore, people's health is also at risk. In other words, the health of living things is in danger, more precisely.”

The interviews with students indicated that they expect the living things on earth will disappear, the decrease in water and agricultural products will cause people to struggle with drought and malnutrition, new diseases will emerge with the melting of glaciers, oxygen will be depleted with the disappearance of trees, lands will be flooded with the rise of water, and the sun's rays will penetrate the earth's surface due to the polluted air layer as the consequences of global warming.

Awareness of global warming

Students were asked what should be done to raise public awareness about global warming. Students' views about the consciousness that can be created against global warming are given in Table 8.

Table 8

Global Warming Awareness

Global warming awareness	f
Public service ads	18
Banners/posters/brochures	13
Official speeches/interview	11
Tree planting campaigns	9
Meetings/protest marches	7
Education/conference/events in schools	5
News/programs/tv series	5
Campaigns/projects	5
Encouraging electricity savings	3
Support of famous people	2
Promoting renewable energy	1

Students stated that awareness against global warming can be created with public service ads ($n=18$), banners/posters/brochures ($n=13$), speeches by officials/interviews ($n=11$), tree planting campaigns ($n=9$), meetings/protest marches ($n=7$), education/conferences/events in schools ($n=5$), news/programs/series ($n=5$), campaigns/projects ($n=5$), encouraging electricity savings ($n=3$), support of famous people ($n=2$) and promoting renewable energy ($n=1$) (Table 9).

DISCUSSION

In the current study, the perceptions of middle school students about the greenhouse effect, global warming, and climate change were examined through semi-structured interviews. This section,

it has tried to summarize the students' perceptions about climate change, the greenhouse effect, and global warming and how they make sense of these concepts.

All the interviewed students agreed that climates have changed. Most students cited the change of seasons, global warming, greenhouse gases/effect, harmful/toxic gases, deodorants, fossil fuels, unsuitable temperatures for the season, industry/factories, human consumption, and deforestation as the causes of climate change. Although, the 8th-grade Ministry of Education textbook (MoNE Science Textbook, 2018, p.31) defines climate change as "All of the changes that occur in the climate are called climate change", students stated that climates change with the increase in Earth's temperature. Most of the students cited the melting of glaciers, decrease/depletion of plant and animal diversity, drought, change in annual average temperatures, increase in sea level, flood, agricultural problems, forest fires, change of seasons, air pollution, change in weather events, severe natural disasters, water pollution, epidemic diseases, and hunger/poverty as the consequences of climate change. Interviews with students also stated that because of climate change, people and other living things will struggle with increasing temperatures, floods, drought, famine, fires, natural disasters, and air pollution, and thus the future of the Earth will be deeply affected. In order to prevent climate change, students recommended installing filters on factory chimneys, reducing greenhouse/toxic/harmful gas emissions, reducing deodorant usage, public transport choice, increasing environmental awareness, renewable energy sources choice, reducing the use of fossil fuels, afforestation, energy savings, using electric vehicles, giving importance to recycling, saving water and stop disproportionate reproduction. On the other hand, Özdem et al. (2014) stated that seventh graders define climate change as a consequence of modern life. They see the issue as personally important, but they also state that there is nothing they can do.

In the 8th-grade textbook, it is stated that if the greenhouse effect did not exist, the temperature of the Earth would be approximately $-18\text{ }^{\circ}\text{C}$, and due to this effect, the temperature of the Earth increased by an average of $32\text{ }^{\circ}\text{C}$, making it suitable for living things. It has also been stated that technology makes life easier, but some products brought to life with technology cause the ozone layer to become thinner and the greenhouse effect to deteriorate. Some of these are perfumes and deodorants, wastes from industrial facilities, factory chimneys and gases from vehicles, and various pesticides. It is stated that the toxic gases from these products have the property of retaining heat, especially the increase in the amount of CO_2 and heat-trapping gases, causing the temperature of the atmosphere to increase. As a result, global warming was defined as the rapid increase in the greenhouse effect and atmospheric temperature (MoNE Science Textbook, 2018, p.191-192). According to interviewed students, the causes of the greenhouse effect are factory gases, deodorants/perfumes, harmful/toxic gases, fossil fuels, cutting down trees/deforestation, humans/unconscious consumption, pollution of seas, environmental pollution, global warming, air pollution, pesticides, and the ozone layer depletion. In the interviews, the students also expressed the

effect of harmful gases regarding the greenhouse effect, the accumulation of harmful gases in the atmosphere and the trapping of the sun's rays by these gases, and the increase in Earth's temperature due to polluted air and harmful gases. The students thought that the consequences of the greenhouse effect are the melting of glaciers, the death of living things/respiratory diseases, the extinction of living things, the change of seasons/climates, air pollution, environmental pollution/change, temperature rise, drought/desertification, global warming, sea level rise, reduction of animal habitats, flood, landslide/erosion, forest fires, hurricanes, depletion of potable water resources, food shortages, mutations, ozone depletion, and acid rains. Niebert and Gropengießer (2014) found the phenomenon of "global warming caused by ozone holes" surprising, considering that ozone layer and ozone depletion are not a part of daily life, and this understanding is not based on daily experiences. Moreover, Liarakou et al. (2011) identified that secondary school students had some misconceptions such as the cause-effect relationship between the greenhouse effect and the depletion of the ozone layer.

In the interviews, the students explained that they heard the concept of global warming everywhere, that global warming is a bad thing, the warming of the world as a result of the greenhouse effect, the increase in the world temperature, and climate change due to the gases released as a result of human effects, the effect caused by the increase of greenhouse gases in the atmosphere, the increase in the temperature of the heat-trapping gases in the Earth. They gave examples of melting of glaciers, temperature rise, sea level rise, animal/human extinction, drought/desertification, diseases/death, climate change, some visible changes/pollution in the environment, weather events, damage to natural habitats, decrease in potable water resources, air pollution, decrease in biodiversity, food shortages, forest fires, mutations, natural disasters, depletion of fossil fuels, wars, perforation of the atmosphere and ebb tide to the consequences of global warming. Students suggested some measures that can be taken against global warming such as installing filters on factory chimneys/cars, afforestation, using renewable energy sources, recycling, choosing public transportation/cycling, reducing fossil fuel use, not using air-conditioning, not using deodorants, saving electricity, using electric vehicles, preventing greenhouse gas emissions, being sensitive to nature/environment, using natural resources using economically/consciously, heat insulation, water saving, reducing detergent use, controlled breeding, using paper instead of plastic, not spilling oil into the sea and legal obligation (tree tax). Furthermore, students mentioned that they take some individual measures against global warming such as not polluting the environment/sensitivity, not using deodorants, transportation by cycling/walking, giving importance to recycling, planting trees, saving energy, preferring public transportation, water saving, using renewable energy, not pouring oils into the sink, not using air conditioning, supporting nature conservation campaigns, protecting forests/trees, not using fossil fuels and choosing electric vehicles. Likewise, Shepardson et al. (2011) stated that students believe that a way can be found for people to adapt and survive the environmental effects of global warming and climate change with new

technologies, but for some students, global warming will cause human deaths as a result of floods, hot water and lack of drinking water (drought). The students stated that the increase in the carbon dioxide level in the atmosphere is largely due to vehicles and factories, so the solution to global warming is to drive less, reduce pollution in general, and reduce the number of polluting factories. In addition, most of the students did not associate the ozone hole with global warming and climate change, indicating that the students became more knowledgeable about the difference between global warming and ozone depletion.

Students stated that global warming has an effect on living things such as the extinction of life, diseases/death, food/water scarcity, habitat damage, mutations, disruption of the food chain, fires, floods, whirlwinds, energy shortage, and skin damage. In the interviews, the students stated that as a result of global warming, the living things on earth will disappear, the decrease in water and agricultural products will cause people to struggle with drought and malnutrition, and new diseases will emerge with the melting of glaciers, oxygen will be depleted with the disappearance of trees, lands will be flooded with the rise of water, and the sun's rays will penetrate the earth's surface due to the polluted air layer. Similarly, Shepardson et al. (2011) mentioned that students expect that global warming will affect plants and animals, causing the death of plants and animals or a decrease in their numbers due to warmer weather or less precipitation. These students also expect that global warming will cause sea level rise due to the melting of polar ice or increased precipitation.

Students stated that awareness against global warming can be created with public service ads, banners/posters/brochures, speeches by officials/interviews, tree planting campaigns, meetings/protest marches, education/conferences/events in schools, news/programs/series, campaigns/projects, encouraging electricity savings, support of famous people and promoting renewable energy. Liarakou et al. (2011) pointed out that television came to the fore as the dominant source of information about climate change and participation in environmental education programs appears to be a critical factor as it clearly influences students' ideas in a positive way. As Lombardi et al. (2013) mentioned that raising a climate-literate citizen must have the idea that discussing alternative explanations can lead to a more informed and open understanding of science. This type of literacy has critical periods for the development of a society that exhibits cognitive mental habits as characteristics and is designed to meet challenges in a way that benefits the global community. According to Özdem (2014), since secondary school students identify their primary sources of information as media and education, climate change should be addressed both in national curricula and in the media in order to provide a correct understanding and awareness.

SUMMARY

In summary, the results indicated that all the interviewed students agree on the changing of climates. Most students cited the change of seasons, global warming, greenhouse gases/effect, harmful/toxic gases, deodorants, and fossil fuels as the main causes of climate change. As the consequences of climate change, most of them cited the melting of glaciers, decrease/depletion of plant and animal diversity, drought, change in annual average temperatures, increase in sea level, flood, agricultural problems, forest fires, change of seasons, air pollution, and change in weather events. They recommended installing filters on factory chimneys, reducing greenhouse/toxic/harmful gas emissions, reducing deodorant usage, public transport choice, increasing environmental awareness, renewable energy sources choice, reducing the use of fossil fuels, afforestation, energy savings, using electric vehicles, giving importance to recycling, and saving water in order to prevent climate change. Students suggested the main causes of greenhouse gases are factory gases, deodorants/perfumes, harmful/toxic gases, fossil fuels, cutting down trees/deforestation, and humans/unconscious consumption. Moreover, they expect the melting of glaciers, the death of living things/respiratory diseases, the extinction of living things, the change of seasons/climates, air pollution, environmental pollution/change, temperature rise, drought/desertification, global warming, sea level rise, and reduction of animal habitats as the consequences of the greenhouse effect. In addition, they gave examples of melting of glaciers, temperature rise, sea level rise, animal/human extinction, drought/desertification, diseases/death, climate change, some visible changes/pollution in the environment, weather events, damage to natural habitats, decrease in potable water resources, air pollution, decrease in biodiversity, food shortages, forest fires, mutations, natural disasters, depletion of fossil fuels, wars, perforation of the atmosphere and ebb tide as the main consequences of global warming. Students suggested some measures that can be taken against global warming such as installing filters on factory chimneys/cars, afforestation, using renewable energy sources, recycling, choosing public transportation/cycling, reducing fossil fuel use, not using air-conditioning, not using deodorants, saving electricity, using electric vehicles, preventing greenhouse gas emissions, and being sensitive to nature/environment. Furthermore, students mentioned that they take some individual measures against global warming such as not polluting the environment/sensitivity, not using deodorants, transportation by cycling/walking, giving importance to recycling, planting trees, saving energy, preferring public transportation, and water saving. Students stated that global warming has an effect on living things such as the extinction of life, diseases/death, food/water scarcity, habitat damage, and mutations. In the interviews, the students stated that as a result of global warming, the living things on earth will disappear, the decrease in water and agricultural products will cause people to struggle with drought and malnutrition, and new diseases will emerge with the melting of glaciers, oxygen will be depleted with the disappearance of trees, lands will be flooded with the rise of water, and the sun's rays will penetrate the earth's surface due to the polluted air layer.

Author(s) Contribution Rate

The authors equally took part in all processes of the article.

Ethical Considerations

The Ethics committee approval was obtained from the Çanakkale Onsekiz Mart University Ethics Committee to conduct the research. Written and verbal consents were also obtained from each student participating in the study.

Conflicts of Interest Statement

The authors declare that there is no conflict of interests.

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APPENDICES

Semi-structured interview questions

1. Do you think climates are changing? Can you explain why?
If the answer is yes; How would you define "Climate Change"?
2. What do you think are the consequences of "Climate Change"?
Do you think that "Climate Change" will affect the future of the world? Why is that?
3. What should be done to prevent "Climate Change"?
4. What does the concept of the "Greenhouse Effect" mean to you?
5. What do you think are the cause(s) of the "Greenhouse Effect"?
6. What are the consequences of the "Greenhouse Effect"? (Hint: Think in terms of the environment. Think in terms of living things.)
7. Some experts claim that the Earth's temperature is increasing. What do you think about this?
8. Have you heard of the term "Global Warming"? Can you explain?
9. What measures can be taken against "Global Warming"?
10. Are there things you do to prevent "Global Warming"? If so, what are they?
What are the consequences of "Global Warming"?
What should be done to raise public awareness about "Global Warming"?
11. What effects does "Global Warming" have on living things?
Do you think that "Global Warming" has an impact on the future of the world? Why is that?
(MoNE Science Textbook, 2018, p.192)