IB Extended Essay on Environmental Systems and Societies

**Research Question:** To what extent is the effect of global warming on the ecosystem in Antarctica irreversible?

Abstract

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Global warming is a concern that should be known and recognized world wide. The purpose of this essay is to determine to what extent is the effect of global warming on the ecosystem of Antarctica irreversible. I investigated and researched the multiple issues and causes that played a role in the state of global warming. The continent of Antarctica is one that holds a large impact in the way the world is today. This is why the question of whether or not the damage that had been done to the ecosystem of Antarctica was irreversible motivated me.

In order to come to a conclusion on my research question, I read and observed multiple articles, images, graphs, and books that dealt with the various topics under the main subject of global warming. A few of these credible sources consisted of the *NASA Scientific Visualization Studio*, Meltdown by Patrick J. Michael, and the *Central Intelligence Agency's Library.* I spent a large amount of my time looking at all accounts and collecting useful data for the subjects I chose to discuss in my essay.

The end result of my investigation was that the effect of global warming on the ecosystem of Antarctica was irreversible. The rise in the climate had caused the polar ice caps to melt and it was no longer refreezing in the winter season, proving that this was permanent.

Despite the fact that the past effect of global warming is irreversible, whether or not the climate continues to rise and effect not only Antarctica's ecosystem, but the world, is up to mankind.

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# Introduction

In the span of hundreds of thousands of years, planet Earth has faced multiple periods of mass extinctions. The most controversial extinction period is known as the Cretaceous-Tertiary (K-T) or more commonly, the extinction that killed the dinosaurs. The Cretaceous-Tertiary extinction period is also known as the most recent extinction, holding such a strong impact on todays society that it is often perceived as the one and only mass extinction that has occurred on Planet Earth. According to researchers such as Peter D. Ward in his novel Rivers in Time: The

Search for Clues to Earth's Mass Extinctions, Earth has had a total of five mass extinctions. These extinctions in order are the Ordovician-Silurian, Late Devonian, Permian, Triassic- Jurassic, and the Cretaceous-Tertiary mass extinction.

In these past five mass extinctions, the earth lacked human presence, and therefore only natural disasters could be held responsible. In the present day however, the Earth is

overpopulated with humans. These humans have, over hundreds of years, destroyed their planet by the over burning of fossil fuels that have emitted greenhouse gases which have subsequently caused the Earth's temperature to increase. In an article by Christine Dell'Amore,*“ Is Species Extinction Happening 1,000 Times Faster Because of Humans?”*, Dell’Amore states that “applying the same statistical approach to extinction data revealed a rate of 100 to 1,000 species are lost per million per year, mostly due to human-caused habitat destruction and climate change.” It is becoming clear that it is no longer natural disasters that we must fear bringing the Earth to its sixth mass extinction, but the human race itself.

# The Anthropocene

The Earth's sixth mass extinction is already popularly referred to as the Anthropocene, or, the era in which we destroy ourselves. According to Richard Godwin in his article titled,

*¨Anthropocene Angst Could Be the End of Us All¨*, ¨In the Anthropocene (dating back to the first plutonium bomb tests in the 1950s) it's humans, not gods or asteroids or tectonic plates, who have the greatest impact on the Earth's biosphere. If we carry on destroying habitats, burning carbon and forgetting to bring our own bags to the supermarket, we will bring about its destruction.¨ When speaking of the situation of the Earth's climate, the concept of the Anthropocene is extremely significant. The Anthropocene is the direct measure of the human impact on Earth and by pointing out its existence, mankind is stating that the impact of our activities is not only global, but irreversible as well. Fiona MacRae Science Editor states in her article titled, *¨Scientists Declare a New Era of History. and It's All Our Fault!¨* that the

¨Anthropocene will be defined geologically by phenomena as diverse as the effects of nuclear

bomb tests, plastic pollution, concrete and soot from power stations. Even the bones left by the global domestication of chickens could be a marker of the new age.” It is significant when talking about the existence and effects of global warming that the Anthropocene is mentioned. As both Godwin and MacRae point out, the Anthropocene is what awaits humanity if the environment continues to be negatively impacted the way it has been for hundreds of years.

# The Melting of the Polar Ice Caps

So where does one look to for clear evidence that the Anthropocene may or may not be approaching? Well, if a rise in the Earth's temperature is what will trigger the next mass extinction, one must observe the speed at which the world's largest ice cube melts, the polar ice caps.

When it comes to spreading awareness of climate risks, NASA is on board. Based on NASA’s monthly updates on the rate of the melting of the ice caps in Antarctica, it is certain that the temperature of the world is rising. The threat of climate change has been recognized for years, yet little to nothing has been done to address it. Nowadays, many activities require the burning of fossil fuels. From the use of cars, airplanes in flight 24 hours a day, appliances that are left running, and buildings being heated and cooled, it is clear that society pushes forward more and more inventions to make life easier without thinking of the serious consequences that come along with their actions. Mankind is destroying its home.

When the topic of global warming is introduced, almost always Antarctica will find its way into the conversation. This is because based on NASA’s recent global temperature records, the Arctic region is not only the coldest place on Earth, but the one place in the world that is most affected by the rise in temperature worldwide. According to the Central Intelligence Agency, the Antarctic region is 5.405 million mi². The Arctic is home to about 4 million people,

even more plants and wildlife, and largely affects the world's sea levels. When a person thinks of Antarctica, they envision below 0 temperatures, furry coats, and never ending snow. They do not stop to think that the coldest place in the world may be melting; that the world's biggest ice cube is becoming the world’s biggest slushie, and along with that, the world's biggest problem.

In Patrick J. Michael's book Meltdown, he begins talking about the issue of global

warming by referring to the Energy Balance Equation: *s*

4

(1- *α* ) = *ε σ T* 4 The equation

states that mankind has the ability to change how hot the surface of the Earth is. S stands for the energy the planet receives from the sun, it is divided by 4 because the earth is split into four parts and the sun only hits one fourth of the earth directly at a time. *α* refers to the energy that is reflected away from Earth. Michael uses the example of snow and how it ¨for example, reflects 90 percent.¨

*e*

In Antarctica, the largest amount of snow is melting, which means less solar radiation.

*α* is subtracted from 1 because this gives the total amount of energy that the Earth absorbs. By deforestation and burning of fossil fuels, mankind can change this amount of energy. *ε* refers to how well the Earth can disperse or scatter heat, and *σ* is the constant between temperature and energy. When A or E is disturbed, heat is redistributed and the Earth's temperature rises

significantly. Lastly, *T* 4 refers to how powerful the heat of the Earth's atmosphere is. Michaels use of an equation to break down the process of mankind and its impact on the earth's surface temperature is significant because it not only places things into a clearer picture, but it shows us what we’re dealing with.

*e*

**Global Land and Ocean Temperature**



*(Data source: NASA's Goddard Institute for Space Studies (GISS). Credit: NASA/GISS)*

As seen in the figure above, around the world usual temperatures have risen, and these climate changes are intense. The graph is a clear demonstration of the drastic changes in the Earth's surface temperature from 1880 to the present day. As seen by the year 2020, NASA predicts that the climate will continue to rise. The graph shows that the ten most warmest years have been the previous ten in history, with 2015 reaching the warmest year ever. This drastic shift in temperature poses a threat to the vulnerable ecosystems and populations all around the world, and especially in the Arctic.

The Arctic is a direct reflection of the state of the Earth, and with the temperature rising, the melting rate of the icecaps is increasing. The following are two maps which illustrates the change in the Arctic sea ice extent. (Figure 1) depicts the North Pole in 2002, and (Figure 2) is a map of the same sea ice extent in the same location in 2012.





**Figure 1 Figure 2**

*(Credits: NASA Goddard's Scientific Visualization Studio/C. Starr)*

The sea ice extent for Antarctica in the North Pole in 2012 compared to 2002 reaches record minimums. According to NASA, arctic sea ice in september 2012 has declined at a rate of more than 13% per decade compared to the previous 30 years. July 2015 was recorded as the warmest month on the entire planet. The maps show clear evidence of the effect of global warming on the melting of the sea ice. Below is a graph from NASA Goddard’s Scientific Visualization Studio Center that portrays the year-to-year ice extents and the significant decline.

Figure 3

*(Credits: NASA Goddard's Scientific Visualization Studio/C. Starr)*

On March 28th, 2016, NASA Goddard's Scientific Visualization Studio/C. Starr stated that, “Every year, the cap of frozen seawater floating on top of the Arctic Ocean and its neighboring seas melts during the spring and summer and grows back in the fall and winter months, reaching its maximum yearly extent between February and April. On March 24, Arctic sea ice extent peaked at 5.607 million square miles (14.52 million square kilometers), a new record low winter maximum extent in the satellite record that started in 1979. It is slightly smaller than the previous record low maximum extent of 5.612 million square miles (14.54

million square kilometers) that occurred last year. The 13 smallest maximum extents on the satellite record have happened in the last 13 years.”

The temperature and carbon dioxide levels in the Arctic are growing at an unprecedented rate. Scientist claim that sea ice will continue to decline significantly and this will increase global warming according to Patrick J. Michaels energy balance equation which states that ice and snow reflect 90% of sunlight. Due to the great decline of ice and snow, less solar radiation will be reflected and instead will be trapped close to the planet's surface therefore increasing the Earth's temperature.

# The Rising Sea Level

Antarctica is made up of about 90% of the Earth's ice, and according to the *Central Intelligence Agency's Library*, if this large percentage of ice were to be melted, the sea levels would rise to about 60 miles. The melting of the ice caps in Antarctica has already caused a significant rise in the sea level. As stated in the book The Attacking Ocean by Brian Fagan, “One hundred and twenty meters and climbing: that’s the amount of sea level rise since the end of the Ice Age some fifteen thousand years ago. Slowly, inexorably, the ascent continues in a warming world.” As the sea level rises, so do many concerns about the long-term effects. Fagan goes on to state that increased global warming “brings a higher incidence of extreme hurricanes and severe gales, and also of tropical cyclones and their sea surges, quite apart from the terrible consequences of tsunamis triggered by earth movements on the ocean floor that devastate coastal settlements.” Although all of these disasters are short-term events, their effects are not only long- term, but deadly. Mankind is now vulnerable to any attacks from an ocean that was once one hundred and twenty meters below today’s shorelines.

The significant rise in sea level has already resulted in many of these disasters. In October of 2012, one of the Atlantic ocean's most devastating hurricanes traveled through the Caribbean and up the East Coast of the United States, destroying anything in its path. This hurricane was known as hurricane Sandy, and it was a disaster that led almost all of those who lived by the seaside to lose their homes. According to the National Hurricane Center, 285 lives were lost in total. The hurricane caused about $315 million in damage in the Caribbean and nearly $62 billion in the United States. Hurricane Sandy made history as one of the largest and most destructive Atlantic hurricanes on record. It isn’t just Hurricane Sandy, but also Katrina and Irene that must be remembered. These hurricanes taught us of the dangers that come with living near the now rising sea level. According to Fagan, “Today the ocean laps at millions of people’s doorsteps - crouched, ready to wreak catastrophic destruction with storm-generated sea surges and floods. We face a future that we are not prepared to handle, and it’s questionable just how much most of us think about it.” The relationship between the melting of the polar ice caps caused by global warming and the sea level rise is significant to how destructive these hurricanes can become.

# The Ecosystem of Antarctica

The ecosystem of Antarctica will be greatly impacted by the climate change. The wildlife in the Arctic is made up of orgasmins that have adapted to the extreme conditions of the coldest place on Earth. Some of the wildlife in Antarctica consist of arctic foxes, reindeer, caribou, whales,walruses, polar bears, fish, seals, penguins, and migratory birds. In the arctic, the entire ecosystem relies on the presence of sea ice. If there's no sea ice, there’s no seals, no polar bears, and overall no life.

Many have already heard of how global warming is affecting the polar bear species in Antarctica. The habitat of the polar bear is key to its survival. Polar bears are extremely dependent on sea ice. On September 14th, 2016, NASA reported that “A new study by University of Washington researchers, funded by NASA and using satellite data from NASA and other agencies, found a trend toward earlier sea ice melt in the spring and later ice growth in the fall across all 19 polar bear subpopulations, which can negatively impact the feeding and breeding capabilities of the bears. The paper, published on Sept. 14 in the journal *The Cryosphere*, is the first to quantify the sea ice changes in each polar bear subpopulation across the entire Arctic region using metrics that are specifically relevant to polar bear biology.”

The sea ice is where polar bears are able to hunt seals and move from one place to the next. Polar bears also rely on the ice when they are hunting; by peering in the ocean from the ice, they use their paws to snatch fish from the water. Pregnant polar bear females need the sea ice in order to build winter dens. These winter dens are made where the snow or ice is thick, and if the sea ice is melting, there is no place for these dens to be made. The mothers and their cubs emerge in the spring, they have not eaten, and they rely on good ice conditions in order to hunt.

A change in the ice extent is detrimental to the survival of the polar bear and has already being noticed by photographer Kerstin Langenberger who is apart of the *Arctic Dreams* organization. Below is a group of photographs taken in 2016 by Langenberger that have flooded the internet.

Figure 4

***(****Credits: Kerstin Langenberger)*

The photographs of this emaciated polar bear began a worldwide discussion about the conditions in Antarctica and how mankind could and should reverse them. Although polar bears have seem to become the only Arctic animal that is being so largely affected, they are small in the large issue that is at hand. Many other animal species extinctions and issues have been linked directly to climate change. In a study published in 2007 in the *Journal Climate Dynamics*, it is shown that if the planet's temperature increases by only 2 degrees celsius, 5% of the Earth's species faces extinction.

Another species at risk are seals in the Arctic that are dependent on ice. These seals consist of the bearded seal, ringed seal, harbour seals, grey seals, and the ribbon seal. These particular seals are at risk because they depend on the sea ice to be there when they give birth and when they nurse their pups. The sea ice is also used as a resting platform for them and to

forage either on the the ice edges or beneath it. Ringed seals are most vulnerable when it comes to global warming because their entire survival relies on the sea ice. The seals require a significant amount of snow in order to construct their homes. If sea ice continues to decline due to the increasing atmospheric temperatures, the seals will be forced to adapt to the drastic change and eventually come onto land. Such a change will place the seal species at risk to land predators, especially newborn seals who are unable to defend themselves, and this will cause a significant decline to the species population.

# Capitalism and Climate Change

Capitalism is the overall drive for climate change, meaning we cannot beat climate change while capitalism goes on. Capitalism is responsible for the buildup of greenhouse gases in the atmosphere caused by the incineration of gas, oil, coal, wood, and other fuels in order to provide energy for the capitalist industry. Capitalist industries also push for deforestation in areas in which they wish to create new factories or establishments in order to create more of a profit.

In the book This Changes Everything by [Naomi Klei](https://www.goodreads.com/author/show/419.Naomi_Klein)n, Klein states “our economic system and our planetary system are now at war. Or, more accurately, our economy is at war with many forms of life on earth, including human life. What the climate needs to avoid collapse is a contraction in humanity’s use of resources; what our economic model demands to avoid collapse is unfettered expansion. Only one of these sets of rules can be changed, and it’s not the laws of nature.” In this quote, Klein points out the main issue that is at hand, there is no way to balance our current capitalist system with our current climate change. Klein goes on to state that the answer to solving climate change is so simple that it is almost achievable. “We have not done the things that are necessary to lower emissions because those things fundamentally conflict with deregulated capitalism, the reigning ideology for the entire period we have been struggling to

find a way out of this crisis. We are stuck because the actions that would give us the best chance of averting catastrophe—and would benefit the vast majority—are extremely threatening to an elite minority that has a stranglehold over our economy, our political process, and most of our major media outlets.” Klein speaks of the United States capitalist system, but it’s not just the United States’ system that must change. Stopping the pollution and mass production that the capitalist system causes requires the teamwork of all continents. We all live on the same planet, which means we all contribute to eithers its downfall or its survival.

# Irreversibility and Climate Change

Climate change is overall irreversible. Dr.Solomon, is a scientist who works for the National Oceanic and Atmospheric Administration, stated in her most recent conference that “if it's irreversible, to me it seems all the more reason you might want to do something about it...Because committing to something that you can't back out of seems to me like a step that you'd want to take even more carefully than something you thought you could reverse." The Earth's thermostat cannot simply be turned down once it has been cranked up, and that is why mankind should begin formulating plans to keep temperature levels from rising anymore. According to Stephanie Sammartino McPherson in Arctic Thaw: Climate Change and the Global Race for

Energy Resources, “more and more ice melts each year over the summer and does not refreeze in the winter.” This is significant because if the ice is not refreezing, the damage that is already done is both permanent and irreversible. Planet Earth seems to be seatbelted in on a manmade ride of climatic destruction from the buildup of carbon dioxide, methane, nitrous oxide, tropospheric ozone, CFC-12, HCFC-22 , and sulfur hexafluoride in the atmosphere. These greenhouse gases have increased the negative effect of global warming on the ecosystem in Antarctica and the world and can only cease to continue if the world agrees to dramatic cuts in

pollution. If not, according to the U.N. panel, “the planet faces a future of extreme weather, rising sea levels and melting polar ice from soaring levels of carbon dioxide and other gases. Only an unprecedented global effort to slash emissions within a relatively short time period will prevent temperatures from crossing a threshold that scientists say could trigger far more dangerous disruptions.”

# Conclusion

In conclusion, reversing the state of global warming as it is now is impossible, but stopping any further damage can be done if the human race acknowledges what is happening and what will happen if we do not take action. Antarctica’s ecosystem is just one of the many that will cease to exist if mankind continues to abuse fossil fuels the way it has for the past hundred years. The sooner we realize our impact and choose to confront the issue of global warming

head-on, the greater chance mankind will have to save the Earth.

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