

SMART ENVIRONMENTS PROJECT

DOCUMENTATION REPORT

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Chapter 0: Introduction

Possibly the biggest worldwide problem in our current society is climate change. Climate change refers to longer-term shifts in temperature, weather and climate in general. The change is caused by an increase of greenhouse gasses emissions over the past century, examples such as carbon dioxide and methane are heat-trapping gasses which get stuck in the Earth's atmosphere. The change in climate results in the warming of Earth's temperature and this causes melting polar ice caps, more extreme weathers, changes in rainfall and a rising sea level. All of these changes greatly affect human health, but also forests, agriculture and animals.

Climate change eventually results in different dangers to our planet and the living beings. Flooding, wildfires, drought and insect outbreaks are all just examples of results of climate change.

The purpose of this report is to create a possibility to protect houses from being destroyed by wildfires, using sensors to detect an immediate danger for that certain house. A smart environment is about the value it provides to its users and the organization, not just the technology. These sensors have the potential to aid the safety of these users of the smart environment. That would be that these sensors would continuously monitor the environment and they would alert the need to initiate protective measures for the house in the situation where that house would be endangered by a wildfire.

Droughts are such a big issue for climate change because when an environment is affected by drought, it is hard to bring that environment to its initial state, therefore the best solution is to find a way to keep droughts under control rather, since to try to get rid of them when they already are affecting a bigger environment is much harder. Drought is not an immediate initiator for wildfires but they do play an important factor. As drought itself can not ignite wildfires, by means of high temperatures or lightning, dry soil makes it easier for a fire to be ignited in collision with heat.

Preventing wildfires would require a lot of research and a lot of time invested into it. That would be something too big for students to attempt so we chose to look at something smaller but still important. Instead of preventing wildfires we intend to create a measure to protect smaller places, such as a garden or a house, from wildfires, making it much more realistic for us. What makes wildfires so toxic for the climate would be all the destruction they create and the toxins that they emit, therefore protecting measures that would stop or hinder the wildfires would be very beneficial.

In California alone, there are more than 2.3 million homes directly exposed to wildfire danger, with an estimated value of \$343 billion. As the damage of the 2020 California Wildfire is estimated around 12 billion, with over 10 thousand buildings destroyed it is considered that the buildings are the greater part of the costs resulting in 5%th of the damage costs. Therefore, salvaging the houses should save the governments a great amount of money.

In 2017 proof has been shown that keeping sprinklers on during a wildfire may cause remarkable effects to rescuing a building. See image:

The sprinklers were, however, only a factor in salvaging this house. A main reason for fire to spread quickly is dry soil. The house owners, however, were able to water the grass in the week before the fire started, soaking the soil just enough. The main reason this house was salvaged was because the firefighters were able to soak the house, since the wet soil gave them enough time to get there and save it. ¹



¹ D. Evon, "Fact check: Did sprinklers save a house from a massive wildfire?," Snopes.com, 16-Oct-2017. [Online]. Available: <https://www.snopes.com/fact-check/did-sprinklers-save-house-from-massive-wildfire/>. [Accessed: 25-Jan-2022].

Chapter 1: Literature Review

1. Next-generation ensemble projections reveal higher climate risks for marine ecosystems

“Next-generation ensemble projections reveal higher climate risks for marine ecosystems” is a paper where data from different sources is combined to create a simulation of marine ecosystems. Multiple simulations are run, the emission is changed in every scenario. The conclusion of the paper is that mitigation of the current emission problem will likely increase the amount of marine wildlife. The simulations also show that there is a lot of uncertainty about what is to happen if we keep these emission numbers up. The mitigation of the current problem will not only increase the amount of marine wildlife but also the foreseeability of the future.²

2. The importance of warm habitat to the growth regime of cold-water fishes

One of the recurring themes of biological adaptation planning is to merge cool rivers with smaller warm beeks. They do this to induce the amount of mobile fish in the water, the sentiment being that these mobile fish have more growth potential. This paper focuses on what happens to the animals that naturally live in these smaller beeks. The results of this paper do not line up with the aforementioned consensus.³

3. Sources of Greenhouse Gas Emissions

This article contains data about the sources of greenhouse gases in the US. Some key points: the economic sectors causing the most pollution are Transportation, electricity and industry.

The emission rate in 2019 has increased by 2% since 1990, in which time the impact by electricity and industry has decreased, and the impact by transportation, commercial/residential and agriculture has increased.⁴

² D. P. Tittensor, C. Novaglio, C. S. Harrison, R. F. Heneghan, N. Barrier, D. Bianchi, L. Bopp, A. Bryndum-Buchholz, G. L. Britten, M. Büchner, W. W. L. Cheung, V. Christensen, M. Coll, J. P. Dunne, T. D. Eddy, J. D. Everett, J. A. Fernandes-Salvador, E. A. Fulton, E. D. Galbraith, D. Gascuel, J. Guiet, J. G. John, J. S. Link, H. K. Lotze, O. Maury, K. Ortega-Cisneros, J. Palacios-Abrantes, C. M. Petrik, H. du Pontavice, J. Rault, A. J. Richardson, L. Shannon, Y.-J. Shin, J. Steenbeek, C. A. Stock, and J. L. Blanchard, “Next-generation ensemble projections reveal higher climate risks for marine ecosystems,” *Nature News*, 21-Oct-2021. [Online]. Available: <https://www.nature.com/articles/s41558-021-01173-9>. [Accessed: 25-Nov-2021].

³ J. B. Armstrong, A. H. Fullerton, C. E. Jordan, J. L. Ebersole, J. R. Bellmore, I. Arismendi, B. E. Penaluna, and G. H. Reeves, “The importance of warm habitat to the growth regime of cold-water fishes,” *Nature News*, 25-Mar-2021. [Online]. Available: <https://www.nature.com/articles/s41558-021-00994-y>. [Accessed: 25-Nov-2021].

⁴ “Source1qs of Greenhouse Gas Emissions,” EPA. [Online]. Available: <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>. [Accessed: 25-Nov-2021].

4. COVID-19: Lessons for the climate change emergency

This scientific article compares the Covid-19 pandemic with climate change. Comparisons are made between the social impact but also the economical impact. “The lesson to be learnt is clear- ignoring the early scientific calls for action ends up being costlier in the long-run, even if these measures appear initially punitive”, is quite an important message which is mentioned multiple times throughout the article. How preventing both crises would have made a difference and what the resulting effect is of not preventing, or being too late. Examples which are mentioned are the irreversible change, the weakening of international solidarity and social and spatial inequality.⁵

5. Is Global Warming Harmful to Human Health?

This paper is about a study on the awareness the public (specifically Americans) has on how much the rising temperatures on planet Earth impact our health. The results of the study show that people overall have a basic knowledge of the fact that global warming can cause health problems. They on the other hand also show that the public does not know what kind of health problems it will exactly bring and which population groups are hit the most by it. This research shows that it is important to put effort into educating people of the problems global warming brings.⁶

6. The state of the climate in 2021

This article discusses the current state of the climate around the globe. A lot of important aspects of climate change are being touched upon. The huge amount of CO2 emissions, the extreme temperatures in certain regions, and the forests that are in rapid decline for example. The amount of CO2 in the atmosphere is still increasing up until now, which will fuel a decline of ice and an increase of the worldwide temperature. Deforestation causes an increase of CO2 and without plants and trees in return less CO2 gets captured as well. This all contributes to the international problem called climate change.⁷

7. Effects of global warming

This article brings into perspective a lot of the side effects of global warming, other than a rise in temperatures. The side effects range from ice melting and causing the

⁵ R. D. Manzanedo and P. Manning, “Covid-19: Lessons for the climate change emergency,” *Science of The Total Environment*, 27-Jun-2020. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S0048969720340857>. [Accessed: 25-Nov-2021].

⁶ E. Maibach, J. Kreslake, C. Roser-Renouf, S. Rosenthal, G. Feinberg, and A. Leiserowitz, “Is global warming harmful to human health?,” *Yale Program on Climate Change Communication*, 22-Feb-2016. [Online]. Available: <https://climatecommunication.yale.edu/publications/do-americans-understand-that-global-warming-is-harmful-to-human-health/>. [Accessed: 25-Nov-2021].

⁷ I. Gerretsen, “The state of the climate in 2021,” *BBC Future*, 11-Jan-2021. [Online]. Available: <https://www.bbc.com/future/article/20210108-where-we-are-on-climate-change-in-five-charts>.

water level to increase yearly to change in weather and more species becoming endangered. In the article they also discuss the possible effects that are to come if global warming continues at the same rate that it has been going on for recently. These include the possible spread of diseases, extreme weather happening more frequently and for some species to go extinct.⁸

8. Global warming will happen faster than we think

The article discusses the problem of global warming and its effects on, for example, wildfires. Rising emissions, declining air pollution and natural climate cycles combined will cause an accelerated effect of climate change. This gives extra pressure to the government to protect the people from the consequences. An estimation that rising greenhouse-gas emission and a decline in air pollution will cause a 1.5 degrees of warming by 2030.⁹

9. The relationship between cows and climate change

The Guardian released an article in October 2021, about the relationship between cows and the climate. In this article it is said that about 14% of all human-induced climate emissions are caused by cows and other farm animals. This is mostly because of methane, and this is also the best way to tackle global warming. Although methane breaks down relatively quickly, it is more harmful than carbon dioxide. That is the reason why getting rid of all the methane would be a great opportunity to tackle global warming. Options to reduce the methane emissions is by cutting down meat and dairy production. The EU's target to reduce emissions by 55% by 2030, is "definitely not fulfillable without reductions in livestock and meat consumption", says Chemnitz.¹⁰

10. Climate change impacts on renewable energy generation

In this article, the negative impact that climate change can have on renewable energy is addressed. Even though renewable energy is one of the main solutions for climate change, climate change itself can hinder the improvement or increase of renewable energy sources. For example, hydropower is affected by the change in temperatures and precipitation since these affect the flow of rivers. Renewable energy from wind is

⁸ "Global warming effects," National Geographic, 03-May-2021. [Online]. Available: <https://www.nationalgeographic.com/environment/article/global-warming-effects>. [Accessed: 25-Nov-2021].

⁹ Y. Xu, V. Ramanathan, and D. G. Victor, "Global warming will happen faster than we think," Nature News, 05-Dec-2018. [Online]. Available: <https://www.nature.com/articles/d41586-018-07586-5>. [Accessed: 25-Nov-2021].

¹⁰ T. Levitt, "What's the beef with cows and the climate crisis?," The Guardian, 27-Oct-2021. [Online]. Available: <https://www.theguardian.com/environment/2021/oct/27/whats-the-beef-with-cows-and-the-climate-crisis>. [Accessed: 25-Nov-2021]

affected by the change in wind speed, change in daily or seasonal distribution of wind and changes in temperatures.¹¹

11. How record wildfires are harming human health

This article discusses the bad effects of toxins in wildfires on human health. Especially the small particles, around 2.5 micrometers, are what are the most to be concerned about. It mainly causes the heart rhythms to be less stable and the lining of the lungs to become inflamed. Research is done on whether the effect of smoke is greater on firefighters than people who are commonly exposed to smoke where it is concluded that close direct exposure is around 15 times more dangerous than 24-hour 35 micrograms exposure.¹²

12. Wildfires, Global Climate Change, and Human Health

This article discusses the correlation between climate change and wildfires and the health effects of wildfires. There has been a big increase in the amount of wildfires in the last few years. Since August 2020 there have been record-breaking amounts of wildfires in the United States. Climate change increases the chances that a wildfire will occur. Wildfires cause a lot of smoke which comes with health risks. Climate change leads to wildfires which possibly leads to more acceleration of climate change which can possibly lead to a feedback loop.¹³

13. Climate change now detectable from any single day of weather at global scale

This article published at the start of 2020 discusses the fact that climate change is now detectable at any single day since 2012, and at a yearly basis since 1999. Detection and attribution studies about external signals in climate properties such as humidity and surface air temperature are mentioned. Furthermore it is mentioned how small local differences in daily temperature can have a great global impact.¹⁴

¹¹ K. Solaun and E. Cerdá, "Climate change impacts on renewable energy generation. A review of Quantitative Projections," *Renewable and Sustainable Energy Reviews*, 27-Sep-2019. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S1364032119306239>. [Accessed: 25-Nov-2021].

¹² M. Kozlov, "How record wildfires are harming human health," *Nature News*, [Accessed: 25-Nov-2021].

¹³ R. Xu, E. Al., Author Affiliations From the School of Public Health and Preventive Medicine, J. Y. and Others, J. K. and Others, E. J. and Others, A. G. and Others, Y. G. and Others, and Y. M. Bar-On and Others, "Wildfires, Global Climate Change, and Human Health: NEJM," *New England Journal of Medicine*, 25-Nov-1970. [Online]. Available: <https://www.nejm.org/doi/full/10.1056/NEJMsr2028985>. [Accessed: 25-Nov-2021].

¹⁴ S. Sippel, N. Meinshausen, E. M. Fischer, E. Székely, and R. Knutti, "Climate change now detectable from any single day of weather at global scale," *Nature News*, 02-Jan-2020. [Online]. Available: <https://www.nature.com/articles/s41558-019-0666-7>. [Accessed: 25-Nov-2021].

14. Climate change and biodiversity

Because of the increasing greenhouse gasses, the temperature is also increasing. This affects the polar regions. Because of this the habitats of polar bears, penguins etc. change and cause shifts in mating cycles of migratory animals. On top of that, the ice is melting, causing the sea level to rise. The sea temperature also has a big effect on zooplankton, which is an essential part of the food chain in the ocean.¹⁵

15. The causes of climate change

This article by nasa gives a general overview of the causes and effects of climate change. The greenhouse gasses include water vapor, carbon dioxide, methane, nitrous oxide and chlorofluorocarbons.

Since the start of the industrial revolution the amount of CO₂ in the atmosphere has increased by 48%

The climate change will most likely result in higher overall temperatures, some areas will become drier and others wetter, increase the sea level, impact crop yields and lead to an increase in natural disasters.¹⁶

16. Is It Too Late To Stop Climate Change? Well, it's Complicated.

This video gives a high-level overview of the causes and potential solutions to global change, with a focus on the societal aspect. Struggles: Increasing global population causes more consumption and thus more emissions. Increasing wealth leads to higher standards of living and more emissions. Rich economies want to keep growing, poor countries want to catch up. Goals: Using energy efficiently is a good start, and increasing wealth allows for investing in more efficient tools. These savings are often spent by doing other damaging activities instead, so the savings can be lower than expected. Increasing energy generation efficiency is another avenue, by discouraging coal and fossil fuel usage and incentivising renewable energy.¹⁷

17. Climate change and the need for agricultural adaptation

This article addresses the fact that in recent years climate change has greatly affected agriculture. Because of increase in temperatures and droughts the global production of cereals was reduced by as much as 10%. The countries that are threatened the most by climate change are the developing countries which are facing improved temperature variability and increased extreme weather events, these are bound to affect their

¹⁵ M. Michelle, "How Does Climate Change Affect Biodiversity?," Sciencing, 02-Mar-2019. [Online]. Available: <https://sciencing.com/climate-change-affect-biodiversity-23158.html>. [Accessed: 25-Nov-2021].

¹⁶ "The Causes of Climate Change," NASA, 30-Aug-2021. [Online]. Available: <https://climate.nasa.gov/causes/>. [Accessed: 25-Nov-2021].

¹⁷ S. Taylor, Ed., "Is it too late to stop climate change? well, it's complicated.," Kurzgesagt, 29-Sep-2020. [Online]. Available: <https://www.youtube.com/watch?v=wbR-5mHI6bo%2F>. [Accessed: 25-Nov-2021].

agriculture. Because of the lack of resources or restricted resources in developing countries they will not be able to properly adapt to these sudden changes.¹⁸

18. Genomic evidence of past and future climate-linked loss in a migratory Arctic fish

How will different taxa respond to the known widespread biodiversity losses because of climate change? This paper wants to answer that question for one of the taxa, arctic fish. Genomics is used in conjunction with environmental modeling to foresee the impact on the arctic fish. It also immerses on what impact the change of the arctic taxa will have on the other ecosystems. This is done by looking at past climate-linked declines in an Arctic species.¹⁹

19. Rising groundwater and sea-level rise

The article discusses that the accuracy between the rising sea levels and groundwater decreases when going further from shore. This causes the problem of the area at risk from the higher water level to extend further than only the sea-level rise. This is a problem because by implementing sea-level-rise adaptation the level of groundwater is not taken into account and therefore leave the coastal communities at higher risk.²⁰

20. Deforestation and Climate Change

This article discusses the relation between climate change and deforestation. There are multiple factors that cause deforestation such as cattle ranching and agriculture. Deforestation plays a big role in greenhouse gas production. 25% of the total greenhouse gas emissions is estimated to come from deforestation. Forests and rainforests are at risk because of deforestation and changes need to be made globally to preserve the existence of these ecological places.²¹

¹⁸ R. Anderson, P. E. Bayer, and D. Edwards, "Climate change and the need for agricultural adaptation," *Current Opinion in Plant Biology*, 11-Feb-2020. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S1369526619301219>. [Accessed: 25-Nov-2021].

¹⁹ K. K. S. Layton, P. V. R. Snelgrove, J. B. Dempson, T. Kess, S. J. Lehnert, P. Bentzen, S. J. Duffy, A. M. Messmer, R. R. E. Stanley, C. DiBacco, S. J. Salisbury, D. E. Ruzzante, C. M. Nugent, M. M. Ferguson, J. S. Leong, B. F. Koop, and I. R. Bradbury, "Genomic evidence of past and future climate-linked loss in a migratory Arctic fish," *Nature News*, 11-Jan-2021. [Online]. Available: <https://www.nature.com/articles/s41558-020-00959-7>. [Accessed: 25-Nov-2021].

²⁰ C. May, "Rising groundwater and sea-level rise," *Nature News*, 17-Aug-2020. [Online]. Available: <https://www.nature.com/articles/s41558-020-0886-x>. [Accessed: 25-Nov-2021].

²¹ "Deforestation and Climate Change," *Climate Institute*. [Online]. Available: <http://climate.org/deforestation-and-climate-change/>. [Accessed: 25-Nov-2021].

Chapter 2: Identification of General Problems and Challenges

1. Underestimation

The main problem which is a recurring theme in most of the publications is the underestimation of climate change. Article 8 discusses this whole theme through how we underestimate the speed in which global warming is rising. Causes for climate change such as rising emissions, declining air pollution and natural climate cycles will cause the global temperature to rise by 1.5°C in 2030.

2. Greenhouse gasses

Gasses which are trapped in the atmosphere are called “Greenhouse gasses”. Some of these gasses are Methane, CarbonDioxide, Nitrous Oxide and other fluorinated gasses. When these gasses get into the atmosphere because of pollution of cars, factories, livestock and many more causes, the atmosphere becomes thicker because of all the small particles of these gasses.

In order to prevent the ice poles from melting, we need to thin out the atmosphere, so the temperatures on earth decrease. If the ice on the poles melts, the sea level increases, and we, especially us in the Netherlands, will get a lot of problems with water like floodings. A very good way is to reduce the emission of methane. This is because livestock plays a big role in the emission of Methane, and we can relatively easy, lessen our Livestock, by reducing meat, and dairy consumption. This method also drastically decreases the nitrous oxide emissions.

Using less fossil fuels can help to decrease the amount of carbon dioxides in the atmosphere.

3. Impact on biodiversity

The biggest affected group are the arctic animals. The habitats of polar bears and penguins have been decreased due to the melting of polar caps. Other land biodiversity are also affected, the mating cycles of migratory animals could also be affected as they rely on seasonal temperatures to indicate their reproductive timing and migration. Ocean biodiversity is also affected by the rise of sea temperatures, but also through increased carbon dioxide which causes acidification. Fish base their migrations on the temperatures, if their current location is not their preferred temperature they will decide to migrate to somewhere else. And even if the smallest animals of the food chain, plankton, are affected by this then the whole ecosystem of the ocean could be damaged. Whales would have less food available and thus whales are affected and this goes on for every animal in the food chain. Disruptions in the food chain would lead to a lack of biodiversity and this could eventually lead to even plants going extinct.

Diverse insects cause pollination, a lack of diverse insects could harm pollination and cause the plants to go extinct.

4. Deforestation

Deforestation is mainly a problem, because the forests are valuable for breathable air, moreover, it also provides homes for many species of plants and animals, food, and medicine. Deforestation is caused by the rise in livestock, agriculture, wildfires, and many more. The increase of agriculture is mostly caused by developing countries that are facing a greater variety of temperature changes. As they are not properly able to adapt to these changes they need more space and therefore trees get decapitated causing deforestation. In the Brazilian Amazon raising cattle also contributes to deforestation as fast food companies used deforested areas to raise cattle. As this problem has just recently been addressed it has already done a lot of destruction to the forests. Lack of forests causes the greenhouse gas production to rise by 25 percent. This problem is not easily solvable, because changes need to be made globally to preserve the existence of these ecological places.

5. Effects on human health

Wildfires caused by climate change have a big impact on our health. The huge amounts of smoke that spread cause a lot of premature deaths. Smoke from wildfires is one of the most harmful forms of pollution for humans due to the variation of toxins it contains. Among others chemicals, soot and carbon monoxide can be found in the smoke. These toxins get breathed in and subsequently get into the bloodstream through tiny openings in the lungs. This causes these premature deaths. Wildfire smoke can also cause eye irritation and other illnesses, with death as the worst possible result. To prevent these health problems caused by wildfires, we need to lower emissions which cause extreme temperatures.

6. Decrease of air pollution

Current emission and trends. If we compare our current greenhouse gas emissions with that of 1990 we are speaking of a 2 percent increase. Looking on a yearly basis can be deceiving because of factors such as the economy or gas prices. In the US the greenhouse gas emissions peaked in 2006 and has been on a steady downfall since. Since 2006 there has been a 13 percent decrease. Reasons for the downward trend are not set in stone but are thought to be a decrease in total energy use and a continued shift from coal to less carbon intensive natural gas and renewables. 13 percent decrease sounds like a lot but the US still produces 6.500 tons of carbon dioxide annually. How come it's so hard to reduce emissions even further? The difficulty in the US is the standardization of fossil fuel dependent machinery combined with capitalism and the indirect conscience

of climate change. We can see this by the sector difference in greenhouse gas emissions. The transportation sector, mainly filled with independent citizens and small businesses has seen an increase of 9 percent since 2014. Whereas the greenhouse gas emissions from production of electricity, a field where the government has exercised more influence has, in the same time frame seen a decrease in greenhouse gas emissions of 27 percent. When it comes to emissions we are somewhere on the right path, however we can see that the government plays an important role in getting us farther along the path.

7. Renewable energy

Renewable energy is one of the best solutions for helping with climate change and reducing global warming. The biggest issue is that the resources that they use in order to create energy are mostly the ones affected by climate change. Wind turbines are generating energy out of a resource that cannot be contained. If climate change affects the flow of certain areas so it becomes too low to generate electricity constantly those wind turbines become useless since they cannot be relocated. The same thing goes with hydroelectric power, if the flow of water becomes so low that the hydroelectric power plant uses more energy that it produces, making that power plant irrational to use.

8. Impact on agriculture

Climate change impacts the yield of crops, which can cause food shortages. Species that are accustomed to a specific climate might have smaller fruits or struggle to survive as the result of changes in the climate. Climate extremes like droughts, floods and extreme temperatures could destroy a harvest, and certain pests thrive under the warmer conditions and damage the plants. Development in plant breeding or genome editing as well as the use of climate-controlled environments could work to lessen the impact of climate change, but these are not feasible for poorer communities and consume more power than traditional farming.

9. Rising sea-levels

A big problem that is caused by climate change is the rising of sea-levels. Due to greenhouse gasses, the global temperature has been increasing. These temperature changes cause glaciers and ice sheets to melt and thermal expansion which makes the sea-levels rise. The rising of the sea-levels causes flooding. Because of this, inhabitable space will be lost.²² This problem is hard to deal with because the melting of ice is not easily reversible. Additionally in underdeveloped countries it's hard to deal with flooding problems.

²²Lindsey. R "Climate Change: Global Sea Level" 14-Aug-2020 Accessed 25 Nov. 2021

<https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level>

Chapter 3: Identification of Relevant Problems

Identify 5 new problems you find relevant, urgent and interesting, not yet been addressed effectively

1. Eco-guilt / eco-anxiety

Eco-guilt is the feeling of guilt over not contributing enough to the fight against global climate change. This can be because of conscious choices, or because of things outside of their control. Not being able to help can cause feelings of shame. Eco-guilt is usually over small individual things. Eco-guilt can lead to burn-out over the topic of climate change.²³

Eco-anxiety is the feeling of dread over the potential disasters caused by climate change. For people living in certain areas the threat of climate change is very direct, with many disasters already linked to climate change.

When the ability to process information and make decisions is hindered by extreme emotional responses due to climate change we speak of Eco-anxiety. A regular amount of emotional responses is healthy and even necessary but in extreme cases these could interfere with our ability to think and act. These extreme emotions can be caused by climate change especially when dramatically portrayed in the news.²⁴

2. Underestimation

Underestimation mostly comes from the lack of information that is offered to the general public. That also is a result of even scientists underestimating the effects that humans have on the environment.²⁵

Because of underestimation people are not taking climate change and global warming seriously. Currently a lot of people don't see the situation realistically and have a much more positive opinion about climate change than the actual situation.

²³ E. Chan, "Struggling with eco-guilt? don't let it get in the way of real climate action," *Vogue India*, 25-Jan-2021. [Online]. Available:

<https://www.vogue.in/culture-and-living/content/struggling-with-eco-guilt-dont-let-it-get-in-the-way-of-real-climate-action>. [Accessed: 25-Jan-2022].

²⁴ S. C. Whitmore-Williams, C. Manning, K. Krygsman, and M. Speiser, "Mental health climate - american psychological association," *Mental health and our changing climate*, Mar-2017. [Online]. Available: <https://www.apa.org/news/press/releases/2017/03/mental-health-climate.pdf>. [Accessed: 25-Jan-2022].

²⁵ J. Guzman, "Scientists have been wildly underestimating climate change effects of oil and Gas," *TheHill*, 20-Feb-2020. [Online]. Available: <https://thehill.com/changing-america/sustainability/environment/483688-scientists-have-been-greatly-underestimating>. [Accessed: 25-Jan-2022].

Another factor that causes such a lack of information about climate change is the poor representation in the media and in news articles. For example, New York Times, one of the biggest newspapers, is not portraying how grave the situation actually is. They are addressing the issue quite a few times yet they don't give the details at their actual extent.²⁶

3. Weather changes

<https://www.conserve-energy-future.com/climatechangeeffects.php>

Climate change is a significant change in the measurements of the climate lasting for an extended period of time. Not only in temperature but also precipitation and wind patterns. The rise of temperature due to climate change has had a significant impact on the climate. This has led to changes in weather patterns such as Irregularities in rainfall, excess rainfall, drought, storms, heat waves are some other effects. These changes lead to different changes that ultimately lead to, for example: the extinction of wildlife, the shift of habitats of animals and more.

Especially dangerous for humans short-term are stronger storms, hurricanes and wildfires. The increase in ocean surface temperature makes the now warm air above it rise up, this is like fuel for hurricanes making them occur more frequently and also more intense and longer lasting. Wildfires are a direct result of the plant ecosystem drying out and being more perceptible to burning.

4. Heat waves

“Over the past decade, daily record high temperatures have occurred twice as often as record lows across the continental United States.” Heat waves have become more common in the west of the United States. If the gas emissions have not decreased by midcentury, then temperatures will rise by 5 degrees Fahrenheit and by the late century temperatures would have risen by 10 degrees Fahrenheit.

Not only does the increase in temperature affect the melting of the polar ice caps, extreme heat also causes drought and wildfires. Because of the consequences and many deaths of wildfires and drought in the United states, it is listed at the fourth place in top 10 deadliest U.S. disasters since 1980. With these extreme temperatures and increased humidity, the body is not able to cool itself, because sweat won't evaporate as quickly as usual, which can cause heat related illnesses.

High temperatures can also affect agriculture, because some crops need water and cool night temperatures, and livestock may get “heat stress” which affects the quality of the

²⁶ R. Sanders, In media coverage of climate change, where are the facts?, 19-Sep-2019. [Online]. Available: <https://news.berkeley.edu/2019/09/19/in-media-coverage-of-climate-change-where-are-the-facts/>. [Accessed: 25-Jan-2022].

meat. When the temperatures increase, extra cooling of certain things is also needed, so more energy is used, when temperatures are high.²⁷

5. Change in water / water cycle being affected

<https://www.unicef.org/stories/water-and-climate-change-10-things-you-should-know>
<https://www.nationalgeographic.org/article/how-climate-change-impacts-water-access/>

One of the main effects of global warming is climate change. That change influences the water cycle causing several problems with the water such as; water shortage, extreme water events, contamination and the rising sea levels.²⁸

a. Water shortage

- i. As the water cycle is being affected, the places of rainfall is slowly limited from certain places increasingly causing water shortages. Because of that according to Unicef 1 out of 4 children will be living in areas with extremely high water stress, as water is also a part of sanitation and hygiene certain illnesses appear leading to deaths. The lack of water resources causes increased competition for water. Not only does the shortage affect, but also the agriculture sector as there is less water in some reservoirs the farmers are left with less water, leading to less crops to be grown, also causing hunger in the end.

b. Extreme water events/floods

- i. *Extreme water events make it more difficult for people to get their fresh drinking water. These events also bring large populations in danger, often causing death as well.*

c. Contamination

- i. Contamination can be addressed in different ways; two of them are hygiene contamination and different kinds of water mixing, which is discussed in the part rising sea levels. The water is contaminated as a result of water related disasters. Causing an increased risk of diseases.

d. Rising sea levels

- i. Rising sea levels are problematic, because they cause fresh water to turn into salt water. Salt water is not drinkable for humans so this problem will

²⁷ Center for Climate and Energy Solutions, 2021. Heat waves and climate change. Heat waves and Climate Change. Available at: <https://www.c2es.org/content/heat-waves-and-climate-change/> [Accessed January 25, 2022].

²⁸ Unicef.org. 2021. *Water and the global climate crisis: 10 things you should know*. [online] Available at: <https://www.unicef.org/stories/water-and-climate-change-10-things-you-should-know> [Accessed 25 January 2022].

Society, N., 2019. *How Climate Change Impacts Water Access*. [online] National Geographic Society. Available at: <https://www.nationalgeographic.org/article/how-climate-change-impacts-water-access/> [Accessed 25 January 2022].

cause a global water shortage and turning saltwater into freshwater again costs a lot of energy and time.

e. Change in temperature

- i. Causes larger amounts of sea water to evaporate. This results in more water vapor getting into the atmosphere and more instances of extreme rainfall. The ground isn't able to absorb the huge amount of water and this will cause other problems like contamination.

Chapter 4: Problem Selection and Motivation

Drought

What is drought?

A drought is a long period of time where an area has a shortage of water. Due to insufficient precipitation, the ground can experience a lack of groundwater and soil moisture. A drought period can last for weeks, months or even years. Drought is a natural recurring phenomenon however, due to climate change, the properties of droughts have become much more extreme and less predictable.

Causes

Drought is caused by low precipitation over an extended period of time. Climate change, ocean temperatures, changes in the local landscape and “jet streams” are all factors that contribute to drought. Jet streams are bands of strong wind that generally blow from west to east all across the globe. Really hot temperatures can make drought worse because the heat evaporates moisture from the soil. The amount of drought in an area also depends on the location of the area, since in some areas there is more precipitation than in others. Areas with less precipitation will become dry earlier than areas with high precipitation. This is because the soil will get much more moisture, if there is more precipitation.

Rain does however not end drought. Although the rain helps during a drought, the drought won't go away. If the water evaporates quickly, then the moisture won't last long enough, causing the drought to return.

Drought is categorized in three different categories, according to how they develop and what impact they have.

The first one is Meteorological drought, which comes down to a big shortage of rainfall, in a specific region. The second one is Agricultural drought. This is when available water supplies are unable to meet the needs of crops or livestock at a particular time.

The last category is Hydrological drought, which is a lack of rainfall persists long enough to deplete surface water (like rivers, reservoirs or streams) and groundwater supplies

Why did we choose this?

Due to the feedback that was received after the last presentation, our group chose to change the topic to make it fit better with the plans that were made. Heatwaves and wildfires were too broad and didn't have enough correlation, thus it was decided to change to a topic that fitted better which was drought.

What effects does this have?

- Drought leaves a big impact on the area that it affects. Because of the lack of water in the area, the living conditions in that area will become really bad. Water is essential to

human survival, without it people can't stay hydrated and crops can't be grown. Poorer countries that mainly rely on agriculture will feel the effects of the drought really hard.

- Drought also is a bigger danger to wildfires, compared to moist ground, which is why having too dry ground is dangerous.
- Deforestation is also partly an effect of drought, because the trees can't live/grow under these conditions, causing them to die, which will then lead to deforestation. Deforestation is bad because the trees help us clean up the atmosphere and surroundings. Without the trees air quality will not improve, but rather worsen.

Chapter 5: Potential Solutions

- 1. Saving houses from forest fires that are caused by droughts the costs for reparations can be spared and used for other purposes. This can be done with sensors for ground humidity and temperature sensors, to measure the dryness of the environment and increasing temperature, to alert of possible danger for wildfires.**
2. Automatically watered crops to save agriculture against droughts.

Sensors in the use of watering crops.
The sensor tells you the ground humidity so you exactly know when the crops need water. This can prevent excessive water use, which can leave more water available for when there is a drought. To also use less water, a drip irrigation system would be ideal together with this sensor.
3. Preventing wildfires from spreading would be a possible solution.

Heat waves are caused by high pressure wind moves around in the atmosphere, pushing warm air towards the ground. If sensors would constantly be measuring the pressure and temperature in the atmosphere above places where there are significantly more wildfires, then the wildfires could possibly be prevented from spreading. Or if prevention of spreading is too hard, then people in the neighborhood can be evacuated and a general warning would be given to everyone in the surrounding area.
4. Alerting a person of exponential growth to save him/her from dangerous drought scenarios.

This is not a direct solution against drought however drought is the cause in this case, therefore this is a potential solution. With the use of a sensor that measures body temperature and air temperature. The sensor will compare the temperature of the person's body and the air temperature and compare those stats to see any exponential growth in body temperature due to the air temperature getting hotter as well. When exponential growth occurs which may become dangerous for the person, the sensor will send a signal to the person.
5. Smart harvesting water, making a distinction between which water should be purified and which not.

With harvesting rainwater houses in case when there is no water to get during droughts. With sensors it can be measured what water should be purified and what water can stay dirty as it is not used for consumption.

Chapter 6: Solution Selection

Our main goal is to use:

A sensor for ground humidity and temperature sensors, to measure the dryness of the environment and increasing temperature, to alarm for possible danger due to wildfires.

Motivation

We chose this solution over the others, because it is one of the most dangerous problems looking at climate change, as wildfires not only cause less forest but dangerous toxins in the air as well. They also strip people and animals of their habitats. Therefore our solution will create a safe environment for the people living close to the forest and give a greater chance for the forest to be saved, before it escalates.

Not only did we choose this subject because of the danger it has to our environment, but also because we already had a quite solid idea for a smart environment, which can prevent wildfires, caused by heat waves. Our solution was to create a network with ground humidity sensors and temperature sensors, which will keep track of the environment to alert when the conditions become vulnerable for wildfires. The ground humidity sensors should measure the humidity of the ground in a forest, so from a distance it can be seen whether or not the ground is dry in a certain area.

Then there are the temperature sensors which will keep track of the temperature in the area. Once the temperatures rise towards a critical temperature, we water the area as a response to these temperatures. Then we send out a warning to authorities, which can then prevent fires.

The idea is to create multiple smaller areas, which have the humidity and temperature sensors connected to an Arduino. Multiple areas are connected with each other through a mesh network. This way it can be seen from a distance whether or not the circumstances are becoming critical for wildfires. We are either going to show physical changes through water drops and a heater or making a simulation and showing the difference through LED's.

So we now have a system that can foresee the possibility of a wildfire. But how are we going to prevent these wildfires from occurring? For this we will be using sprinklers connected to local lakes, these sprinkler lines can be laid in advance and if kept well can last for a long time. These can be laid down in danger zones like in front of mountains where hot air piles up. Water airplanes that are usually reserved for when the wildfire has already unleashed can also be put to use to wet the parts that will be too dry in the near future.

What preventive measures can we take if we see that there is too much drought for the sprinklers and water airplanes to handle? The first thing that we can do is warn civilians in the area. We won't evacuate them but warn everyone so they are prepared to evacuate if the situation gets worse.

We have come up with two options for containing possible wildfires. The first option takes more preparation and would be done as soon as there is information that a summer is going to be especially warm and dry. It would be to create a grid of ditches that can close off different areas by filling them with water. This can contain a wildfire in a certain area.

The second option will also contain the wildfire in a certain area. However, this time it does not require the amount of preparation the ditches take. By controlling fire in a circle around the existing fire you can burn all the fuel of the fire. If done in a circle, this can prevent a bigger fire and keep it in a small area.

Protecting a garden

Saving houses from forest fires that are caused by droughts the costs for reparations can be spared and used for other purposes. This can be done with sensors for ground humidity and temperature sensors, to measure the dryness of the environment and increasing temperature, to alert of possible danger for wildfires.

Since the previous idea mentioned might be a bit too hard to realize for eight first year students, we modified our idea and the scale on what we want to operate on. That is how we came up with our smaller scale idea, which is to operate on saving gardens. House owners can use this smart environment in their garden, to avoid fires reaching their house, by using water sprinklers in their garden, in combination with sensors, that track temperatures and ground humidity. The only change in idea is thus basically only downscaling the size, from a complete forest, to a garden. Sensors installed in the garden or on the edge monitor temperatures and ground humidity, and if an algorithm decides there is a high risk of a fire, sprinklers will automatically activate to try and keep the house safe from the fire.

For our project, a small-scale physical model will simulate a fire approaching a house that is protected by this system. To realize this idea we used almost the same task division as the previous idea, but adapted some minor details to adjust it to the current situation.

Task Division

Overall process tracker

Adieb (Teamleader)	Scheduling Constructing the presentations. Formatting the final document
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Research team

Alexia	Research humidity to know when we have to set off the sprinklers.
Adieb (research leader)	Research Temperature to find out more about the threshold

	Practical validation research
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Constructing the model

Tion (model leader)	Draw the schematics of the model Build the sprinkler system In charge of purchasing for the model
Ashley	Positioning of the LEDs
Melissa	Idealization of the model (computered) Create the container of the model Literature validation research

Technical side

Marinus (technical leader)	- Receive sensor data - Send data - Drive LEDs (simulation forest fire) Practical validation research In charge of purchasing for arduino team
Brend and Jorick	(Arduino) Compute data (Arduino) Drive pump Processing Practical validation research

We will take into account the information used for the current project to create propositions and a possible solution for the ambitious project. Therefore, our literature research in the end may contain not directly relevant information as this information could be used later on, by us or others, for the initial ambitious plan.

Model proposition

Ideation of the model



When a fire is detected, sprinklers activate.



Recommended materials

Outside box:

- Poplar wood

For the house:

- LEGO

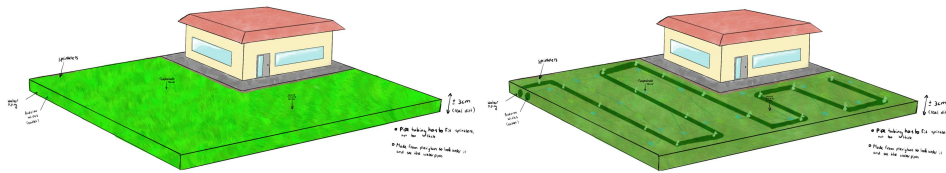
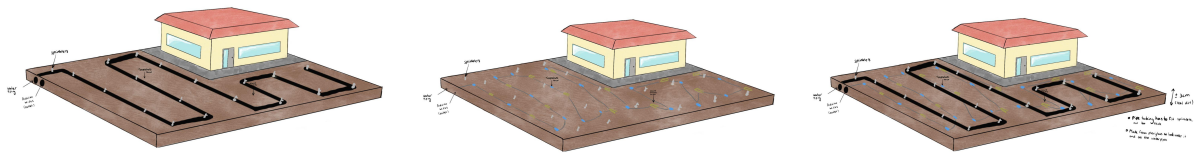
Inside box:

- Tape to make waterproof

Soil:

- sand

Finalization model drawn



Chapter 7: Methodology

What data to collect

- Humidity in the earth
- Temperature above the ground
- Humidity in the air
- Ground temperature

Equipment and expenses

The equipment will be bought from university outlets and alternatively online.

Equipment	Costs
Soil temperature and humidity sensors	€7,-
Air temperature sensors DHT11	Borrowed from SmartXp
ESP32 microcontroller	Borrowed from Marinus
Water pump	€11,99
Pipe (with holes)	€9,99
Lego house	Borrowed from Ashley
Poplar wood	DesignLab (free)
10 LEDs	Borrowed from Marinus
10 resistors	Borrowed from Marinus
Wires	Borrowed from/donated by various group members
Breadboard	Borrowed from friend
Relay	Borrowed from Jorick
Sand	€2,39

Data collection

The data coming from the sensors will be collected from them via a WIFI and Bluetooth connection. This data contains the humidity and temperature of the ground and the temperature of the air. We are also using the most recent weather forecast information to make our system as accurate as possible. This will be obtained from the internet via WIFI connection.

Data analysis

Data will be used to predict where wildfires are likely to start, as well as where it's likely to spread to. By comparing the measured humidity and temperature with historic data, irregularities can be detected and the risk of fire can be calculated. The temperature, humidity and wind direction can be used to predict the spread of the fire.

Chapter 8: Validation

Validate your results through some tests and/or some scientific evaluation process

To validate the results of the findings an experiment was set up. The set up consisted of a stretch of dirt covered by flammable material. The test consisted of trying to set the material on fire and see how quickly it would burn when the soil and the material was dry in comparison with wet soil and material.

Hypothesis

It was predicted that the material and soil that are dry will burn faster than wet material and soil.

Materials

- Dirt
- Water
- Spray bottle
- Lighter
- Scale
- Blowdryer
- Flammable material

Methodology

Preparation

1. Fill a spray bottle with water
2. Measure the weight of the bottle with water
3. Spray 10 times and measure it again
4. Divide multiple patches of flammable material in equal parts
5. Take 300g of dirt and put it on a patch of 20x50cm
6. Dry the dirt with a blowdryer till the dirt is at an appropriate level of dryness

Execution

1. Measure the humidity level of the soil
2. Put the flammable material on the dirt and light it on fire
3. Measure the humidity level of the soil
4. Repeat the process whilst increasing the moisture levels each time

For the validation research has been done beforehand if it was possible to achieve our goal before we began with our finalized project, this is mentioned in the introduction of the paper.

Chapter 9: Results and Conclusion

Results

Using dry hay as flammable material

Water spray measurement: 100 sprays has 77g difference, 1 spray = 0.77ml water

0 water sprays - 0 ml water - moisture sensor output of 440: fire burns quickly

15 water sprays - 12 ml water - moisture sensor output of 630: fire burns up until the wet area, where it gets stopped temporarily until the water evaporates.

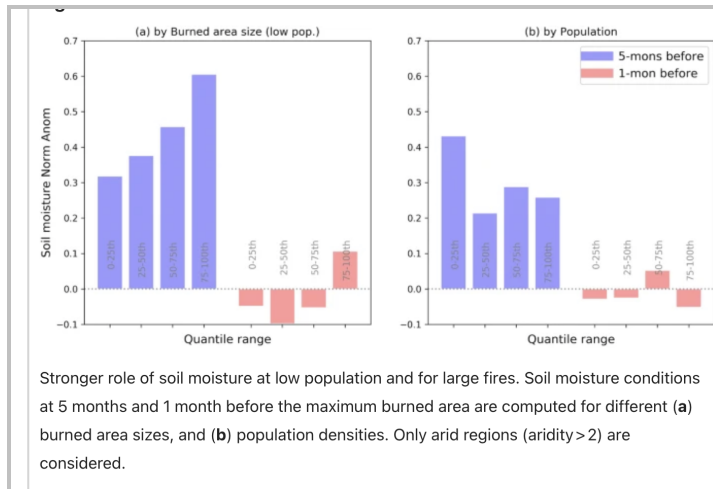
Although the fire does get held back by the water, the water eventually evaporates at which point the fire passes through.

A future test could be if a constant supply of water could stop a fire, and how large this supply should be.

Soil moisture

Current studies show that before a fire there is a considerable decrease in the soil moisture in that area. These studies show that the soil moisture drops from a higher than normal level to a lower than normal in an average period of 5-6 months.

For our project in theory if we raise the level of the soil moisture to one higher than normal, similar to the places where forest fires usually occur, then the fire would ideally be stopped. But the issue here is that we don't have access to those 5-6 months of data about the moisture in the soil that we use so we also don't know what the normal moisture level for the soil is.



Temperature

During the research it was deemed quite difficult to find research and findings about wildfires which correlate with our project. Wildfire research often discusses the long-term effects of climate change and how that increases the chance of a big wildfire, or the chance of it spreading quicker. Researchers have indicated that according to the meteorological variables during 2001-2020 in Sierra Nevada, a 1°C temperature increase also increases the likelihood of fire occurrence with about 19-22%. With this projection it is estimated that by about 2040, the amount of wildfires will increase by $51 \pm 32\%$.²⁹

Scaling up the project

During the selection of the problem that our team was going to tackle, it was clear that there were multiple directions that the project could be headed towards. One of these directions was a more difficult approach to the problem that lies a little beyond the original scope of the project. This approach was to measure factors that could cause an increased risk of wildfires over a larger area. This data could then be mapped and visualized to show potential risk zones of wildfires. This idea seems to have a lot of potential however it didn't seem realistically achievable for our group with the resources and time our group had at the moment.

²⁹ A. A. Gutierrez, S. Hantson, J. T. Randerson, B. Langenbrunner, Y. Jin, and M. L. Goulden, "Wildfire response to changing daily ... - science.org," Wildfire response to changing daily temperature extremes in California's Sierra Nevada, 17-Nov-2021. [Online]. Available: <https://www.science.org/doi/10.1126/sciadv.abe6417>. [Accessed: 25-Jan-2022].

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