Thank you for your invitation. Like I said, today, I will present some of my basic work, my information gathering phase to say it like that, on the relation between artificial intelligence and sustainability. And I will present that a little bit as a difficult ethical conundrum.

I have a slide prepared, showing my background, but as the introduction already covered that, I will not do that again. But I do want to emphasize the fact that because of my background and philosophy in theology and in healthcare ethics, my approach to artificial intelligence is less a technical one.

I admit my technical knowledge of artificial intelligence is quite minimal. But I approach artificial intelligence much more from a societal and a political perspective. As said, I work at the Bonn Sustainable AI Lab. This is our nice building. If people would ever want to come and visit us, you can always reach out.

But then to talk about today's topic, artificial intelligence and sustainability, I will approach this in two, in four different phases. So first of all, I will sketch a little bit, the context in which we are talking about artificial intelligence and sustainability, namely a context of natural crises, let's call it as it is. And then I will sketch a little bit about artificial intelligence. But as you already have been talking and learning about that quite a lot, I also will not pay too much attention about that.

After that, the main focus of this presentation is artificial intelligence and sustainability, which I indeed will divide in these two different perspectives on it, namely using artificial intelligence for sustainability for natural end goals to say it like that. And on the other hand, the sustainability of artificial intelligence itself. I will, the bigger part of this reflection of the sketch will be on the sustainability of artificial intelligence.

And then lastly, and as time allows, I will show you or develop some steps forward to deal with these issues that I will sketch today.

So to start and to set the context, let us have a very quick look at the different natural crises that we are experiencing today globally. And of course, the most talked about and the biggest one maybe is the climate crisis. We all know that we are being confronted with changing weather patterns for changing temperatures, with rising sea levels with increasing acidity levels of the sea with loss of land loss of biodiversity.

One of the major reasons of this is the fact that we as humans, and some parts of the world more than others use technology that emit certain greenhouse gases such as carbon dioxide, methane, fluorocarbons, and so on. And although we see that the increase of these emissions are slowing down, there is still an increase. And we can state for example, that since 1990, worldwide emissions of greenhouse gases have increased by almost 50%. And as such, this, of course, causes certain climate disturbances. It's also very clear that the cause of this climate crisis lies in how we use and

develop the technologies that we use in everyday life, that we use in industry that we use in healthcare, and so on. So the problem is deeply rooted in what we could say, a modern way of life.

This also leads to the conclusion that the responsibilities for this crisis are much more on part of the global north, as their history with these technologies, it's much more extensive than the responsibilities in the global south. And although most of the attention and public debate, I would say is focused on the current climate crisis, let us not forget that we are also confronted with another crisis, not namely the biodiversity crisis.

For example, we see a numbers of the living planet report that in the past 50 years 70% of global biodiversity has been reduced. This means indeed that some animals have become extinct, but it mainly means that in specific species numbers have dropped drastically. For example, the IUCN Red List, a very important document reporting on biodiversity states that more than 42,000 species, animal species are threatened with extinction. For example, 41% of amphibian species, 30% of bird species, 20% of mammals, and so on. Also, insects are heavily impacted by how we live on the planet, agriculture, for example, and these kind of practices. It is stated in the Red List that at least more than 2300 species of insects are threatened with extinction, and for example, also 250 tree species of corals. Apart from these animal species, insect species, also forests, also plants are heavily impacted. Each year, for example, 5 million hectares of forests are lost. This is a size bigger than the Netherlands. And of this loss of forests, at least 95% is taking place in tropical woods, such as the Amazon and the Congo Basin in Africa. We can also see that of plants, species of plants, there is an increase of the number that are critically endangered.

So also, the biodiversity is a very urgent crisis. Not so long ago in Montreal, there was a big gathering of politicians to debate what could be done about this. And it is also stated that the biodiversity and the climate crisis actually strengthen each other. For example, loss of forests leads to more CO2 in the atmosphere, and so on. And it is also in this context that artificial intelligence is being developed and being used.

I will use a very common definition of artificial intelligence, a very basic one. So artificial intelligence being defined as the ability of machines to mimic and perform human or animal-like cognitive functions. And these functions include reasoning, learning, problem solving, decision making, and even the attempt to match elements of human behavior such as creativity.

Then in the AI space, we have all these different distinctions between different models between different conceptions, we can speak about narrow AI, so AI that is specifically developed for a specific problem or a situation, so a little bit more rule based. Or we can speak about general AI, this idea of hyper intelligence of AI becoming smarter or more intelligent than humans.

But for me, and correct me if I'm wrong, for me, I perceive AI mainly as automated statistical analysis, data analysis, pattern analysis, predictive analysis, and this automation increases in an exponential

way, speed of it. Others, then also, we could also talk about machine learning and deep learning as specific models, as specific systems.

But in this presentation, I will speak about artificial intelligence in a more general sense, more from this societal political perspective. It's also not weird that as AI is being developed and used in this context of these natural crises, that we start to think about the possible applications of AI to help us with these natural crises. It's, in a sense, a logical consequence.

But this, of course, leads us to a specific ethical conundrum, namely the fact that we are looking at the technologies, in a certain sense, that has have brought us here in this context of crises. And we are now looking at them to also help us to get us out of these crises. As you can see, in the citation, it seems that our natural environment is becoming more technologized, mechanized, in that sense. And this also leads to the question, could our technologies itself become more natural, become more earthly, become more adjusted to natural processes?

In AI, we can then talk about AI and sustainability, this could be one response to this conundrum. And as such, sustainable AI, a turn point by Professor Wilhelmsburg, in an article of 2021, we can differentiate two perspectives on it. Indeed, like I said before, the use of artificial intelligence for sustainability, for natural environmental goals, to help us to deal with the natural crises. And we can also look, on the other hand, at the sustainability of artificial intelligence itself.

Sustainability, when we talk about that in the public domain, is mostly conceived as sustainable development, which is a very classic perspective on sustainability, namely development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

And then we look at it most of the time from a three pillar model. Sustainability consists of a pillar of ecological sustainability, that consists of a pillar of economic sustainability, and it consists of a pillar of social sustainability. But here in this presentation, we will mainly focus on ecological sustainability, and sometimes touch upon social sustainability. So what do we then mean with the use of artificial intelligence for sustainability? Well, here, when we talk about it, most of the time, we conceive artificial intelligence as this kind of isolated digital tool, all these different singular models that could be used to combat the natural crises. And here, the emphasis lies on the prediction, the analysis capabilities of artificial intelligence, so that we can mitigate or adapt to the effects of climate change and biodiversity loss.

For example, the promises made that artificial intelligence will make our current economic and social practices increasingly efficient, by which their impact on the natural environment would decrease, while we are still able to live our current standard of life. We can think, for example, of making energy production and energy consumption more efficient, we can think of making resource allocation more efficient, we can think of making agricultural practices more efficient. So really, this emphasis of making things more smooth, more robust, more efficient.

Another example would be that we use artificial intelligence to combat or to predict climate change effects, biodiversity loss effects. For example, it is said that artificial intelligence could be used to predict the development of forest fires. And so see how these would predict a certain area, natural area, so that we can actively act upon it to prevent increased harm. One can think, for example, now the fires in Canada, AI could also enable us, for example, to predict how poachers will hunt in a specific natural environment. And so we could then increase the security of that natural environment, protect that natural environment.

It is said that artificial intelligence can help us to predict the rising sea levels and the loss of land, and as such, can prepare us to see how we can intervene with these rising levels with this loss of land can help us to better understand industrial pollution, our own carbon footprint and all these different practices, economic and social practices. And finally, for example, artificial intelligence can also be used to assess the validity of the policies that we as a society, our politicians develop and make to combat to adapt to mitigate climate change, biodiversity loss effects.

We can so test these policies and certain models and see what the outcome is. For example, we can use it to see what impact is of electrical vehicle sharing in a specific city. Does that have benefits for the surrounding natural environment? What are these benefits, and so on. So as you can hear, it seems that the possibilities of AI to help us with natural crisis seem to be inexhaustible. It seemed to be this kind of technical fix for a lot of our current problems.

But nevertheless, my colleagues and me argue that artificial intelligence can only be used for natural sustainability goals when the technology itself is developed and used in a sustainable manner, meaning that the technology that AI itself does not impact the natural environment, environment negatively. And then to get insight into these possible impacts that the development and the use of artificial intelligence itself can have on the natural environment, we argue that we need to go beyond this perspective of artificial intelligence as this isolated digital technological object.

We try to conceive artificial intelligence and our own work as a kind of world object, an object that affect the world as a whole, the communities and networks, but also the world as Earth. So a bit emphasis on the natural environment, and not just a small corner of it. And by perceiving artificial intelligence as this kind of world object, we identify at least three global interrelated networks that enable us to produce artificial intelligence that enable us or that enables artificial intelligence to exist. These three global networks, these three global infrastructures, if you will, are a social environmental network, the social technical network and a digital.

So what I will do in the coming slides is to pinpoint very specific issues, environmental issues on each of these in each of these different networks. And let us start with the social environmental network. Without nature, we cannot produce technical objects by which we cannot produce artificial intelligence. So we need to look at this environmental network first.

And here, two practices already show us the very difficult issues that arise with the development of artificial intelligence, and to be honest, also other digital technologies. For example, the practice of mining, mining to to excavate the necessary natural minerals, minerals, and ores that we need them to develop specific technological objects that we then need to produce artificial intelligence. Mining itself, as you can see here in these pictures have has a grave impact on local natural environments. It destroys natural environments, local natural environments by which it has detrimental effects on the local biodiversity.

The mining industry itself is responsible currently for 10% of the global CO2 emissions, which, for example, in comparison with the aviation industry, is five times as much as that industry. Mining also makes use of very heavy metals to extract the different minerals from the ores from the soil and the rocks, increasing the risk of local pollution of the local soil and the local water supplies and streams.

And of course, all these effects, all these issues, all these impacts also have an effect on the local human health, the health of the local human population, increasing, for example, risks for certain diseases such as cancer, such as specific lung diseases, and so on. And we also know that many of these practices are being carried out in labor conditions, which are very bad, some even touching upon human rights violations. So mining is indeed a very difficult issue, but a very urgent issue that we need to deal with when we speak about sustainable AI.

The third image that you see here is electronic waste, which is also a very big issue, and one that is not talked enough about enough in the context of artificial intelligence. So in 2019, yeah, in 2019, we had as a global community, more than 53 million tons of e-waste was produced in 2019. That in itself was already an increase of 20% in a period of five years. And it's estimated that by 2030, we will have 75 million tons of e-waste every year. Needs to be remarked here that only a small set 80% of this waste is being managed in a formal way, meaning recycling, meaning processed to different resources, etc. Meaning that the other 82%, 83% is dumped in illegal landfills, such you have big ones, for example, in Ghana and Africa, or is recycled by informal workers of which many are women and children.

It's clear that this waste and the processing of this waste can have strong impacts on the natural, the local natural environment and the local communities. Most of this waste is being burned so that the minerals that these electronics contain, such as gold, silver, copper, can be freed up, leading again to pollution of the soil, water, the air, and so also impact human health. Rain on this electronic waste can also lead to poisonous leak leakages again, causing pollution.

So here you see a little bit issues at the beginning of our development of artificial intelligence, and also the aftermath of our use of artificial intelligence. So let us then look at the socio technical or socio techno network.

Many of these minerals are done in a step further being processed into materials that can be put together can be used to develop the technical objects that we then need to produce artificial

intelligence. The right picture here you see a data center of common data center. And this data center, of course, exists out of all these different technical objects such as computer chips, semiconductors, processors, electric wiring, and so on. And it's especially on this on the semiconductor that I want to focus here. So an article of the Guardian of 2022 based on a report of Greenpeace in 2019, it was stated that the biggest chip supplier of the world, the Taiwanese company Taiwan semiconductor manufacturing company used in 2019 5% of all electricity that was produced in Taiwan. So this is one factory, one company that uses 5% of all electricity. And in 2022, this rose to 7.2%.

Of course, the use of this electricity means that this company is also responsible for emitting the related CO2 emissions of this electricity use. But to be fair, the company is trying to develop cleaner energy by using electricity that was produced by windmills and other practices. So it does try to reduce its CO2 emissions. But nevertheless, we are then still confronted with other issues. chip development uses a lot of water, for example, the company itself, the Taiwanese company itself used 63 million tons of water in 2019, which contributed to increasing local droughts and its surrounding area. In 2021, this even led to a confrontation between the Taiwanese company and the local farmers of whom their farming grounds were completely dried out.

Another example to characterize this a little bit is the Intel compass in Arizona, and the United States, the company itself in 2021, produced over for 15,000 tons of waste, but 60% was hazardous. And the company itself also used in 2021 35 million tons of water, which equals the amount of 14,000 Olympic swimming pools. And so it is logical to reason that with the increasing use of artificial intelligence and other digital technologies. Also, this use of electricity, water, production of waste will increase. Here, you also see electric wiring, but that I will have to skip otherwise, I will run out of time. But here the problem lies, for example, with plastic waste.

And then finally, let us focus on the digital networks. So these data centers are one part of this infrastructure that enables us to develop this digital networks of artificial intelligence. And again, here we are confronted at least with problems of water and problems of electricity use.

A very recent study done by colleagues of the University of California in the United States, calculated that the training of an artificial intelligence model suggests GPT-3, so the predecessor of GPT-4 and Jet GPT, directly consumed 700,000 liters of clean water, which is for example, enough to develop 370 BMW cars. It was also argued in a paper that if these data centers were located in specific parts of Asia, for example, the amount of water would have increased, the needed water would have increased by a factor three.

Also, the use of an AI model such as GPT-3 needs a lot of water. It was calculated in that same study that conversation with this model existing between 20 to 50 questions and answers uses 500 milliliters of water. If we think that's true, and this system, this AI system is being used by let's say billions of people in a routine manner. Again, we see these numbers rise exponentially.

And then finally, a study done by now famous study done by Emma Strubel and colleagues, the University of Massachusetts calculated that the training of a natural language processing model consisting of 60 GPU processors emitted around 34,000 kilograms of CO2. An average human in the world produces 11,000 kilograms of CO2 a year. So such as the other two described networks, it seems that this digital network also has invisible impacts which needs to be visible.

So I gave you a lot of info, I gave you a lot of numbers, a lot of issues that we are confronted with. So where do we go from here? Well, I would argue based on what I told you today, that before we even start to debate possible uses of artificial intelligence for sustainable natural goals, we need to have this debate about sustainability of artificial intelligence.

First of all, the awareness about AI as a world object. So AI, in this relation to these different networks needs to increase. AI is mostly still seen in the public, but also by certain politicians as this kind of digital, immaterial technology that lives somewhere in the cloud or something, which does not comply with reality as it is.

We also need, yeah, together with that awareness, it is very important that tech companies and especially big tech companies who have this kind of, this kind of, who are responsible for the most known and the biggest AI models need to be held accountable for these different impacts, and at the very minimum need to become transparent about these different issues that I sketched today.

Momentarily, in the EU, at least we see that there is this kind of policy momentum related to both legislation related to the natural crises and also related to artificial intelligence. And I would argue that these are seen as separate issues. I would argue that these policy frameworks, these legislative frameworks start to learn from each other and start to become integrated.

Environmental issues are not separated from technological artificial intelligence issues. So it becomes mandatory that also our politicians become aware of these issues. And we also need to think in the end, what do we need artificial intelligence for? So we need to make or we need to start to have this debate about what is a need for artificial intelligence and what is a wish for which we would like to use artificial intelligence, this distinction between needs and more desires related to artificial intelligence.

So I've heard that after this presentation and the Q&A, you will go into groups and to have a deeper discussion about this. So I would like to give you one last reflection question that you can take along. Namely the question, can we as local human communities and also as a global human community, envision artificial intelligence technologies that do not have the sketched impacts? How would such technology look like? How would it work?

I thank you for your attention. And here are the references if you would be interested. Thank you very much.