AI-Waste: Analyzing Environmental Impacts of AI Technologies in Developing Countries

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

One of the most prominent problems the world is tackling today is the problem of sustainability: the usage of natural resources in a manner that will not compromise the ability of people and the planet to prosper in the future. The most recent Intergovernmental Panel on Climate Change (IPCC) report continues to affirm several effects of human-caused climate change on the atmosphere, ocean, and biosphere (Calvin et al., 2023). They conclude that the increased severity of extreme weather events, such as floods, droughts, or storms, directly and acutely impact the food and water security of billions of people worldwide. Importantly, they note that the negative climate impacts disproportionately affect vulnerable populations in countries that have contributed least to human-caused climate change.

Historically, these developing countries have struggled with climate regulation. Research has found an inverted U-shaped relationship between several pollutants and economic development called the Environmental Kuznets Curve (Dinda, 2004). This means that developing countries often have a spike in environmental impact as they begin to industrialize and adopt new technologies. Developed countries often lend support for developing countries in the form of technology. However, if done too hastily or without the proper regulation, these donations can have significant environmental consequences ultimately harming the countries they are meant to help.

One of the most prominent emerging technologies is artificial intelligence (AI). AI algorithms allow computers to perform many advanced tasks such as image recognition, autonomous vehicle navigation, or natural language processing that would otherwise not be possible. However, the training and use of AI uses tremendous amounts of power. As AI spreads to developing countries, it is important that the environmental consequences of its use are taken

into account. My research aims to answer the question of: *How will AI technologies in developing countries affect the environment and how does this impact the way developed countries support these developing countries?* Historically, the introduction of computer technology into developing countries has caused problems such as unsafe processing of electronic waste. Therefore, it is important we learn from our mistakes and take into account all the consequences of AI technologies in developing countries.

Background and Literature

Governments and companies from developed countries try to invest in developing countries to spur their growth. This is called foreign direct investment (FDI) and is considered a good way for both parties to mutually benefit. However, we should be careful with the ways in which we invest in developing countries. Current research shows that foreign direct investment (FDI) into developing countries negatively impacts the environment (Opoku & Boachie, 2020). Developing countries historically are often gifted with used computing technology because computing technology considered to be a major contributing factor in the economic growth of developed countries. Research affirms the effectiveness of these IT investments in developing countries (Dedrick et al., 2013). Unfortunately as these computers reach their end of life, they are discarded or recycled using unsafe techniques that endanger the environment. The problem of unregulated and unsafe recycling of computer components is called e-waste. Research shows that e-waste is a continuing and growing problem whose negative impacts often affect women and children who work at unsafe recycling facilities (Perkins et al., 2014; Shittu et al., 2021). The rapid adoption and gifting of computers to developing countries without the proper infrastructure led to a continuing environmental hazard for these developing countries.

Recent advancements in AI technology have led to an explosion of new technological solutions. However, the environmental impacts of AI are also being called into question. AI can be used to combat climate change for example with efficient energy distribution in a smart grid. However, training AI models and running AI inferences is environmentally costly. For instance, the training of a single model can emit 600,000 pounds of carbon dioxide equivalents (Strubell et al., 2019) while 5 to 50 queries of a large language model such as ChatGPT uses around half a liter of water, significantly more than a traditional search engine queries (George et al., 2023). Even environmental scientists developing current environmental AI solutions often do not properly evaluate the environmental impact of their own models (Ligozat et al., 2022). Despite the efforts to improve environmental awareness and green technologies, we still fail to properly evaluate our solutions, especially the technological solutions. In the future, as AI technologies spread to developing countries, the environmental impacts of AI will only multiply.

STS Theory

I will use Actor Network Theory (ANT) to analyze the system of interactions between developing countries, developed countries, and the environment. ANT broadens the traditional definition of an actor to include both humans and nonhumans that impact a system. We can use ANT to visualize and understand the motivations and outcomes of a system by investigating the relationships and interactions between the several actors.

One of the greatest challenges of investigating and mitigating human climate impacts is the several levels of detachment between causes and effects. ANT is a useful technique for analyzing these environmental systems because it makes direct and indirect connections with the environment clear. In addition, treating technologies as actors can help simplify how we understand the evolution and impact of technology. Instead of treating technology as a means

through which humans interact, we can focus on each human actor's interactions with technology.

Methods

My research primarily focuses on AI companies that are creating solutions for developing countries. I have investigated 4 companies whose AI solutions are being used in developing countries. The companies investigated are Microsoft, Zipline, Eneza Education, and One Concern. The companies were chosen to represent a wide variety of fields including medicine, agriculture, and disaster relief. For each company, I searched the tabs on the main website for the company to find sustainability related statements. After collecting data from each company, I found the corresponding countries in which each company was based and selected several countries in which their solutions were being implemented. For each of these countries, I found climate policies or any climate agreements the country has signed. If possible, I also looked for any policies or statements by the country that dealt with the intersection between AI and the environment. Lastly, I collected data on the impacts of climate change on the countries I researched as the impacts of climate change may be a motivator for countries' and companies' actions.

The goal of my research is to identify discrepancies between company policies and countries' environmental goals. Any discrepancies can indicate potential for policy changes so that the incentives of different entities are properly aligned. In addition, a failure to acknowledge environmental impacts of products would indicate a lack of foresight by these companies and a greater potential for negative environmental impacts as these products are deployed in developing countries. In addition, this research will highlight the attitudes of several different groups of actors in our sociotechnical system.

Results

The first and biggest company I investigated is Microsoft. Microsoft is a multi-trillion dollar tech giant with a wide range of services such as servers and server applications or software development tools. As a leader in AI technology, they have deployed several AI solutions in developing countries such as their Digital Agriculture project to help farmers make predictions about their crops to boost food production in India (*Digital Agriculture,* 2017). As a large multinational company, Microsoft has signed several agreements and pledges to reduce their emissions over the next decade (*Environmental Compliance,* n.d.). In addition, they list several commitments on their website to environmental goals such as carbon emissions, water usage, the construction of a "Planetary Computer", a huge database interface for environmental data meant to give others the ability to perform better research and construct better solutions for the environment (*Microsoft Planetary Computer*, n.d.).

Zipline is a company that designs delivery drones. The original purpose of the drone was to deliver medical products to hospitals in Rwanda, but they have expanded their product to assist other African countries as well as provide commercial delivery services in developed countries. Zipline drones use computer vision, a type of AI that allows computers to identify objects in pictures or videos, to navigate and land. Although the company doesn't explicitly have environmental policies or goals, one of the primary advantages the company claims for their drones is that the electric drones reduce carbon emissions when compared with traditional deliveries by truck (*Zipline Drone Delivery & Logistics*, n.d.). This means that their company is at least environmentally aware even if they do not have explicit policies.

The next subfield of AI I investigated was education. Many education companies have begun to use AI to give more personalized learning for students. Eneza Education is an education

company based in Kenya whose primary goal is to give African children better access to education (*Eneza Education*, n.d.). They use an AI chatbot to resolve several user questions. On their website, they do not mention the environment in any of their mission statements and I could not find an environmentally related post on their blog.

The last company I investigated was One Concern, an AI company that produces several infrastructure related AI models (*One Concern*, n.d.). Two of their products, Seismic Concern and Flood Concern, are damage predictors for earthquakes and floods, respectively. One Concern partnered with the World Bank to bring their models to developing countries (*One Concern - The Index Project*, n.d.). The company's website does not explicitly comment on the environmental impact of their products or mention sustainability in their "About" page. However, because their products are generally focused on infrastructure and business risk, they mention how companies have historically "been paralyzed by climate uncertainties" and that their products can help predict this risk. However, these comments do not seem to indicate that the company values the resolution of climate change and unsustainable practices. Instead their focus is to assist with coping with the effects of climate change.

Over the four companies, Eneza Education was the only company not based in California. For this reason, I looked at some of the climate goals of the US and Kenya to see if the policies of their corresponding companies could be linked to the countries in which they were based. In addition, I collected data on the climate effects experienced by these countries to understand how this could impact policies and company awareness.

The US is the largest national economy in the world and simultaneously second largest emitter of carbon dioxide only behind China (US EPA, 2016). The US alone is responsible for around 15% of the world's carbon emissions. Since 2005, US carbon emissions have declined

due primarily to the transition to natural gas from coal and the increased use of green power generation. The US has signed many climate agreements and pledges. One of the most important of these agreements is the Paris Climate Agreement, which the US resigned in 2021 (Blinken, 2021). Notably, the US left the Paris Climate Agreement in 2017 when President Trump took office, which highlights the divisiveness of climate issues in the US. The current white house supports several climate goals such as net-zero emissions by 2050 (*National Climate Task Force*, n.d.). In addition, the US collects lots of data related to climate change. For instance, much of the data collected in this paper is from US departments that have mandates to maintain up to date climate data and reports. As a leader in AI technology, the US Congress has recently proposed some legislation regarding the intersection of AI and climate change. The *Artificial Intelligence Environmental Impacts Act of 2024* is a democrat bill introduced in the senate that would mandate EPA research on the climate impact of AI as well as a National Institute of Standards and Technology (NIST) standard for the quantification of AI climate impact. All of this goes to show that the US has a strong interest in the environment although these initiatives often are politically contentious.

Since several of the companies I researched are based in California and California is considered the "AI capital of the world," I also collected climate policies of California. California is one of the states with the greatest volume of passed climate policy ("State Climate Policy Map," n.d.). Although this does not necessarily mean it has the strongest or most aggressive climate policies, it does indicate that climate is an important concern for California. The Environmental Protection Agency (EPA) also highlights California as one of the states that has experienced some of the largest effects of climate change such as regions with greater than 3.5 degree Fahrenheit change in temperatures over the last 100 years, which has changed water

availability and led to wildfires causing billions of dollars in damages (*What Climate Change Means for California*, 2016.).

Kenya is a low-middle income country that is pushing to become a newly industrialized, middle-income country. According to the US Agency for International Development (USAID) Climate Change Fact Sheet, Kenya is a leading country in climate policy in Africa (*USAID Kenya Climate Change Fact Sheet*, n.d.). They have passed the Climate Change Act and National Climate Change Action Plan in the past decade to lower their carbon footprint and support sustainable development. These steps have been taken despite Kenya's minor impact on global emissions of just 0.1 percent. In addition, the USAID concludes that Kenya's primary economic sectors, rainfed agriculture, tourism, and natural resources, are vulnerable to climate change. To help with Kenya's sustainable development, the US has several multi-billion dollar programs that have built clean power plants and implemented Kenya's Ending Drought Emergencies framework.

Discussion

The general environmental awareness of the companies I investigated was okay. Most of them at least had some involvement or mention of climate issues on their websites. On the other hand, many of the countries that mentioned the environment, did not directly address the climate impact of their products that are deployed in developing countries. One could argue that large companies, such as Microsoft, with many AI related projects ought to focus on overall sustainability of their company and not on the sustainability of an individual project. However, doing this can easily lead to the diffusion of responsibility that characterizes several negative climate decisions. Teams may begin to neglect their own emissions due to the insignificance of their emissions relative to the total company-wide emissions. Focusing on overall sustainability

of the company also goes against several proposals such as Green AI that argue environmental efficiency should be an evaluation criteria in all projects (Schwartz et al., 2019).

Looking at the positions and policies of the US and Kenya, we can see that both countries have ambitious goals for emissions reduction in the upcoming decade. In addition, a large portion of AI companies are based in California which has more climate policy than most other states in the US. Given this, it seems that there is a lack of environmental focus within the companies that are developing AI solutions for developing countries relative to the governments in the locations the companies are located.

Using ANT, we can identify weaknesses in interactions that could cause the difference in environmental awareness between companies and their corresponding governments. A first guess would be weakness in the interaction between governments and their companies. In other words, there is a weakness in the environmental policies or regulations for these companies. Theoretically a proper alignment of goals and policy should align incentives in a way that companies' actions reflect the goals of the country.

We can also analyze the interaction between government and the general public to explain the discrepancy in environmental awareness between companies and government. In the US, climate issues are often very contentious. Thus a possible explanation for the awareness discrepancy could be misaligned incentives within the government. Government officials may have constituents on both sides of climate legislation. This may lead to weak climate legislation that gives the appearance of supporting the environmental movement while bringing about only the minimal changes within companies.

Another potential weakness in the interaction between the public and the government would be low general environmental literacy. Although there is no recent report on US

environmental literacy, historically this is a problem the US has struggled with. For instance, a 2005 report by the The National Environmental Education Foundation, a congressionally chartered non-profit for environmental education, found that the generally US citizens are "both uninformed and misinformed" about environmental topics. Furthermore, there are many ongoing environmental education initiatives such as the NOAA Environmental Literacy Program which has spent $6.3 million on several environmental education projects over the past few years (NOAA, n.d.). These initiatives indicate the ongoing need for environmental education in the US. The issue of weak policies may indicate the inability for the general public to discern good environmental decisions and policies, hindering the adoption of truly impactful policies. If we improve the environmental literacy of the public, then we would strengthen the interaction between the public and the government, then this may lead to better environmental policies for companies.

The other major actor in our sociotechnical system is the companies that are producing AI technologies. Instead of focusing on the government side, the lack of environmental awareness and planning within companies could be a result of the lack of emphasis on sustainability within professional organizations. For instance, the addition of explicit environmentally focused provisions to professional codes of ethics may help direct the design of companies' products. If products are designed to be environmentally sustainable, then this will become a profitable advertising point for the company. As an example for this, *Zipline* used the reduced emissions from their drones as an alternative to car or truck delivery as an advertising point on their website (*Zipline Drone Delivery & Logistics*, n.d.).

Another notable observation through my results is the lack of AI legislation related to the environment. Through my searching, the only notable US legislation on AI's environmental

impact is the *Artificial Intelligence Environmental Impacts Act of 2024*, which still is yet to pass the senate. The historical lack of AI regulation is not surprising given that AI is a relatively new technology. However, it is clear that there is much work to be done in environmental policy and monitoring of AI. It is possible that increased environmental policies around AI would mitigate the awareness discrepancy I found through my research.

Conclusion

The analysis in this paper indicates that most AI companies creating solutions for developing countries acknowledge the challenge of climate change. However, these companies often do not address their own environmental impact and responsibilities within their specific products. In general, relative to the countries or states in which the companies are located, the companies themselves have lower environmental awareness. These results indicate that there is potential for better alignment of incentives for companies and the government.

Future work can further investigate the chain of incentives that leads to companies' investments in developing countries and their environmental goals. This would give further insight into the results found in this paper and also could lead to more concrete policy recommendations. It is also important to continue monitoring environmental policy for AI as we would expect the volume of relevant laws to increase with the recent popularity of AI. It is important that research on this topic keeps up with the evolving nature of the technology.

Overall, my research identifies potential weaknesses in our society that can lead to poor environmental outcomes. With the rise of AI and rapid development and deployment of AI technologies, it is important that we remain aware of the environmental impacts of our decisions, especially in the context of developing countries. The lack of awareness that currently exists can be mitigated by solutions within the government, AI companies, and the public. Looking to the

future, it is important that we enhance collaboration between governments, companies, and the public to address these challenges effectively.

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