The Hidden Costs of AI: Impact on Climate

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1. Introduction

A recent study by Forbes revealed that ChatGPT's daily energy consumption is equal to 2.9 million kilowatt-hours, equivalent to the total energy usage of over 100,000 households (Gordon, 2024). Since most global energy production relies heavily on fossil fuels, as energy consumption rises, so do carbon emissions. This trend raises concerns as the demand for artificial intelligence continues to soar, leading to a larger carbon footprint. However, it is uncertain who will face the worst consequences of this environmental damage. We hypothesize that energy consumption rises as global investment in AI grows, resulting in higher carbon emissions and rising temperatures. This disproportionally affects developing countries, which often lack the resources to address or mitigate the environmental consequences.

2. Data Source and Methodology

Our analysis consists of data from *Our World in Data*, *datahub.io*, and the *Public EM-DAT*. Datasets from *Our World in Data* include Private Investments in Artificial Intelligence, Per Capita CO_2 Emissions vs. Per Capita Energy Consumption, and Per Capita Energy from Fossil Fuels, Nuclear Energy, and Renewable Energy. The Private Investments in AI data range from 2013 to 2023 for 100+ individual countries. The Per Capita CO_2 Emissions vs. Per Capita Energy Consumption data provides CO_2 emissions and energy consumption for 250+ countries from 1965 to 2023. The Per Capita Energy from Fossil Fuels, Nuclear, and Renewable Energy details the source breakdown of energy consumption for 100+ countries from 1965 to 2023. The global temperature dataset (from *datahub.io*) provides the monthly average temperature changes in degrees Celsius from 1850 to the present. Lastly, the data from the *Public EM-DAT (Emergency Events Database)* is a global database that tracks the occurrence and impact of natural disasters.

This analysis examines AI investment across countries using a time series line plot. It then explores energy consumption and carbon footprints with stacked area charts. Next, it investigates global temperature rise and emergency event trends through bar and line plots, comparing findings with climate-vulnerable developing nations. Finally, all variables are analyzed together using a correlation matrix.

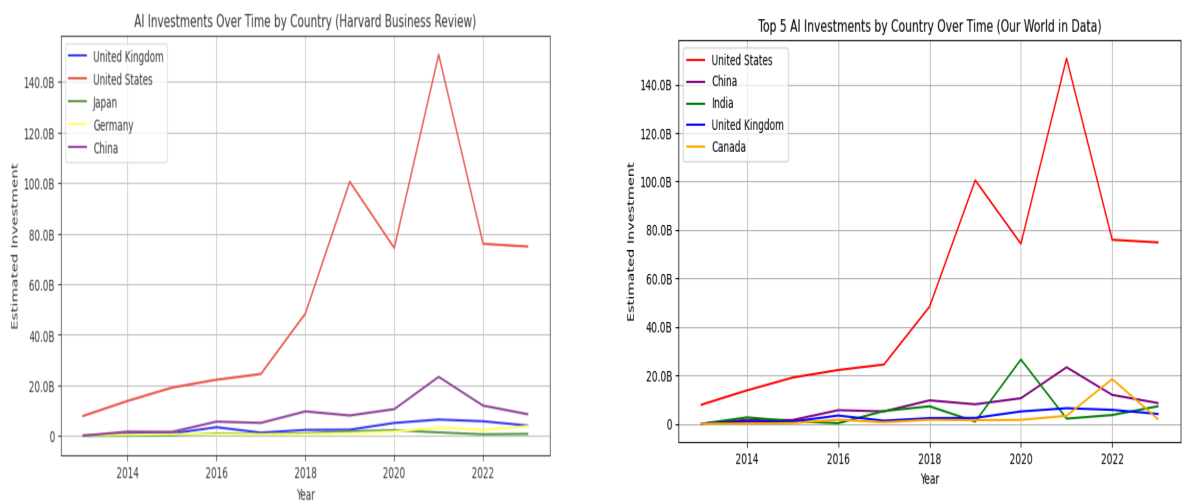
3. Key Insights & Data Visualizations

3.1 AI Private Investment: The emergence of AI within the last decade has led to limited data sources on AI energy consumption. So, we shifted our focus to AI investment trends over time. According to the *Harvard Business Review*, the top five leading countries for artificial intelligence are the United States, China, the United Kingdom, Japan, and Germany. *Our World in Data* provides information on annual private investment in artificial intelligence from 2013 to 2023. The dataset includes countries and their investment amounts by year. However, it only covers private-market investments, such as venture capital, while excluding significant investments from public companies and government funding. This exclusion limits the dataset's coverage of total global AI investments. Thus, we decided to focus on private investments to assess how big technology companies have impacted the growth of AI. *Our World in Data* collected information from companies based on keyword and industry tags classified as AI-related. This methodology introduced limitations, as it may have included firms not traditionally considered AI-focused while omitting others due to the classification criteria. Another limitation of the dataset is the influence of one-time events, such as large acquisitions, which can create outliers in yearly figures. Interest rates and financial market conditions can impact investment levels, even without AI-specific developments.

After considering these limitations, we examined whether the *Harvard Business Review*'s claim that the United States, China, the United Kingdom, Japan, and Germany were the top AI investors. To validate this, we organized the dataset to display countries and their estimated investments. Sorting the data from highest to lowest investment, we found that the top five private investors were the United States, China, India, the United Kingdom, and Canada. This finding differs from the *Harvard Business Review*'s original ranking, which listed the United States, China, the United Kingdom, Japan, and Germany as the top five countries.

This discrepancy may be due to the dataset's limitations as well as differences in the variables *Harvard Business Review* used to measure global AI investments. *Harvard Business Review* included variables such as talent (the quality and quantity of AI talent available), investment (investment flows into AI and emerging technology), diversity (diversity of AI talent), and evolution of the digital economy (development of a country's digital foundations). Analyzing the *Our World in Data* dataset, we observed a significant gap between the U.S. and the other top investing countries. Between 2017 and 2019, AI investments in the U.S. increased by $80 billion, and another rise occurred between 2020 and 2021, which may be related to the COVID-19 pandemic.

Figure 1: Top 5 Countries in AI Investments (Harvard Business Review vs. Our World in Data)



For Figure 2, we plotted all the nations' investments into one graph. Based on the plot above, we can easily identify the United States as the top investing country between 2013 and 2023. Various countries increased their AI investments from 2020 onwards, but nowhere near as much as the U.S. *Please reference the **ai_investment.html** file for a full interactive plot.* As shown in Figure 3, Global AI private investment has generally increased since 2013, with a significant peak in 2021, likely due to the pandemic-driven shift toward technology. Since then, investment levels have stabilized around pre-pandemic levels. While the data shows an upward trend, it likely underestimates total national investments due to limited availability.

Figure 2: Private AI Investment Trends by Country

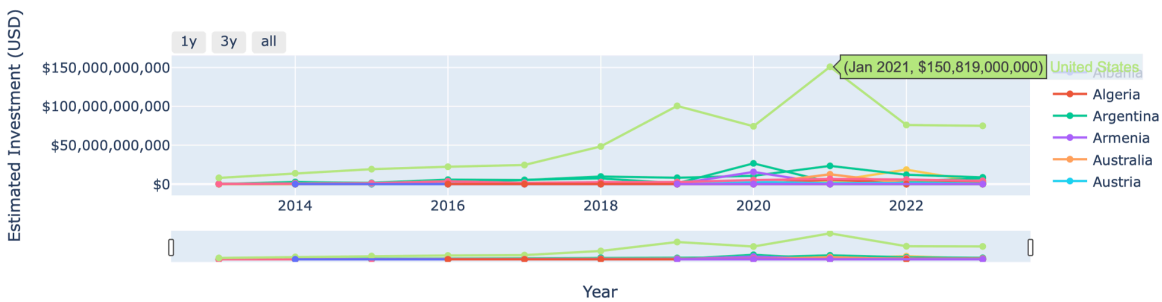
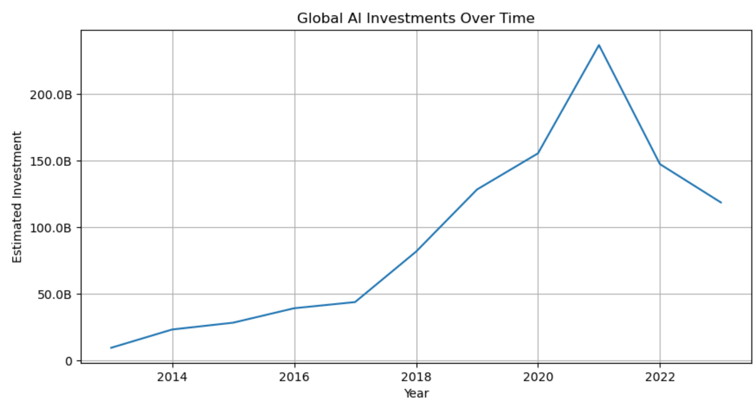


Figure 3: Global Net Private AI Investments (in billions)



3.2 Fluctuating Energy Consumption and Carbon Emissions Trends: With the growing interest and investment in advancing AI models in recent years, the energy demand from data centers should also be rising, along with carbon emissions. We will determine if the AI trends match energy consumption and carbon emissions over time. To account for differences in population sizes across countries, we focus on per capita energy consumption and per capita carbon emissions in our analysis.

Figure 4 illustrates the relationship between energy consumption per capita, carbon emissions per capita, and private AI investment over time. The U.S. remains the largest AI investor, consistently positioned in the upper right, reflecting high energy consumption and emissions. Over time, more countries, particularly in North America, Asia, and Europe, have increased AI investment, with rising energy use and emissions. The analysis will next examine major AI contributors to assess whether their energy trends align with this pattern. *Please reference the* ***energy_emission_ai.html*** *file to interact with the plot.*

Figure 4: Global Energy Consumption vs. CO_2 Emission vs. AI Investment

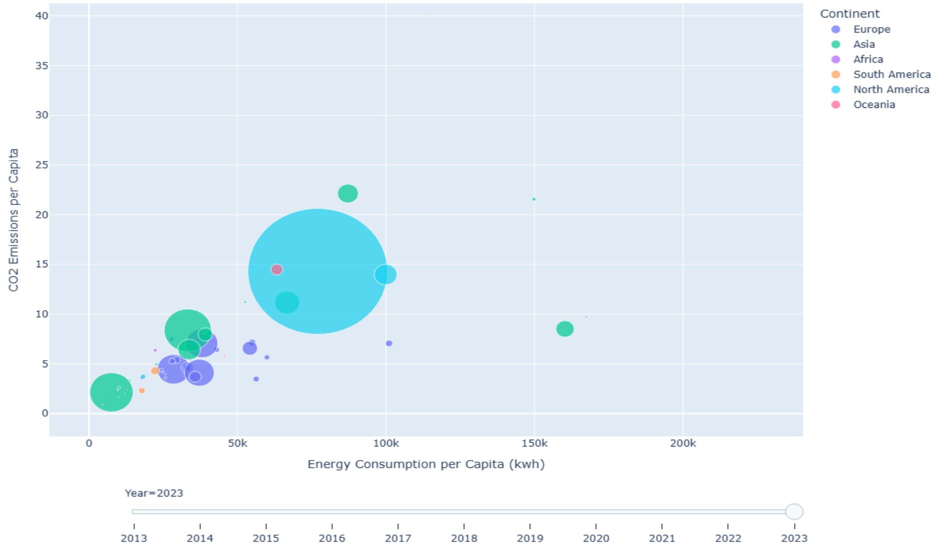


Figure 5 examines energy consumption per capita in the top five AI-investing countries and the global average from 1990 to 2023. While China, India, and the global average have seen rising energy use, the U.S., U.K., and Canada have leveled off or declined, challenging the assumption that AI investment directly drives energy consumption growth. However, Western nations still consume significantly more energy per capita than the others. For every entity, we find that fossil fuels remain the dominant energy source, prompting further investigation into their impact on carbon emissions over time.

Figure 5: Energy Consumption Trends in Top AI-Investing Countries

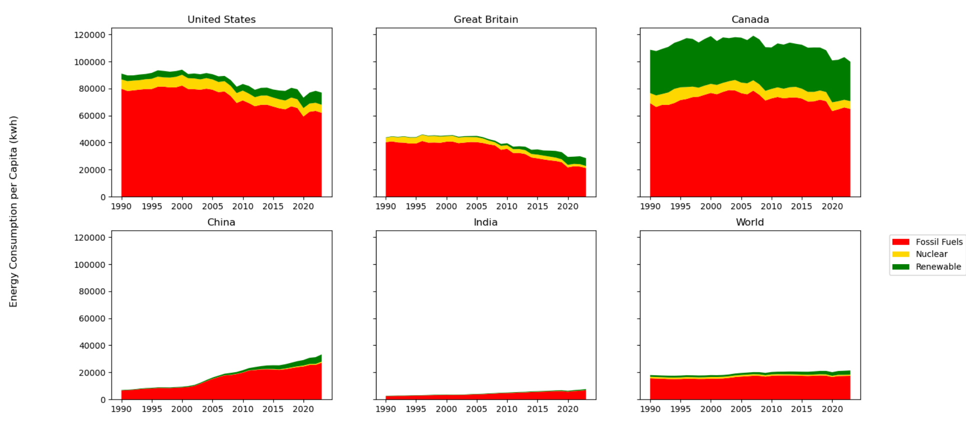
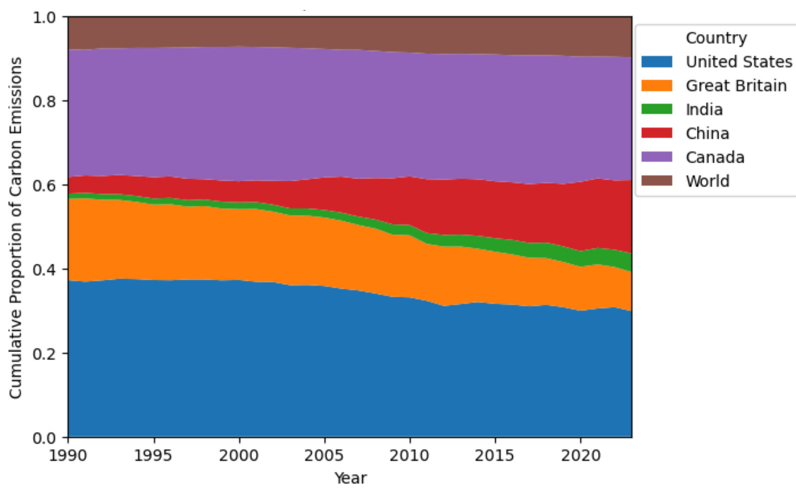


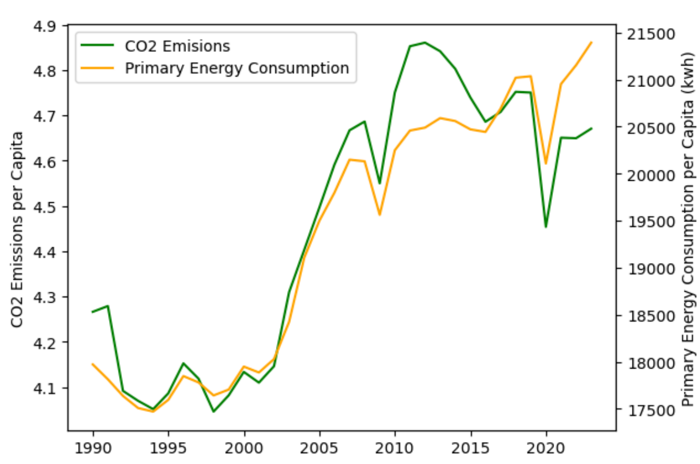
Figure 6 shows the relative proportion of carbon emissions per capita over time. While the U.S. and Canada have stabilized emissions and the U.K. has reduced them, China, India, and the global average have seen continued increases, aligning with fossil fuel consumption trends. So, it is not entirely clear that the trends in private AI investment have a direct correlation with the energy consumption and carbon emissions for major investors. There are several possible reasons for these Western country anomalies. One possibility is that countries like the U.S., Great Britain, and Canada have decreased their carbon emissions due to a shift away from fossil fuel-based consumption in favor of renewable (e.g., solar, wind, hydro) or nuclear energy sources, which do not emit greenhouse gases into the atmosphere. Another possibility is that these higher-income countries have stricter, more developed energy policies that have helped them accommodate the rise of AI while curbing carbon emissions.

Figure 6: Carbon Emissions Distribution Trend for Top AI-Investing Countries



Globally, energy consumption and carbon emissions per capita have risen over the past 30+ years, with temporary dips during the 2008 financial crisis and the 2020 COVID-19 pandemic (Figure 7). While some Western countries, such as the U.S., Great Britain, and Canada, have managed to reduce their carbon emissions per capita over time, other nations may lack the resources or policies to do the same. Unfortunately, some countries are not prioritizing carbon emissions reductions, undermining the progress made by others. As a result, global energy consumption and carbon emissions per capita have continued to rise. With AI continuing to advance rapidly, countries will need to intensify their efforts to mitigate the environmental costs.

Figure 7: Global Energy Consumption & Carbon Emission per Capita



3.3 Natural Disasters: A Consequence of Rising Temperatures: The increased carbon emissions resulting from AI investments contribute to the rise in global temperatures. The average global temperature has increased from approximately 0.4°C in 1990 to 1.1°C in 2023, recording one of the warmest years in the world's history. Particularly between 2010 and 2020, global temperature saw a sharp rise, which coincided with the massive surge in AI-related investments. The rise in global temperatures has profound implications for natural disasters, and Figure 8 shows this striking correlation. According to the Environmental Protection Agency, higher temperature is associated with rapid changes in weather patterns, leading to more frequent and dangerous hurricanes, wildfires, floods, and droughts. In 2023, the world witnessed over 400 occurrences of natural disasters, highlighting a 3-fold increase in hydrological events since the 1990s in the face of rising global temperature. A total of 80 hydrological hazard events were reported only in Asia, which caused over 2000 fatalities with over 9 million people affected.

Figure 8: Global Temperature vs. Disaster from 1990 to 2023

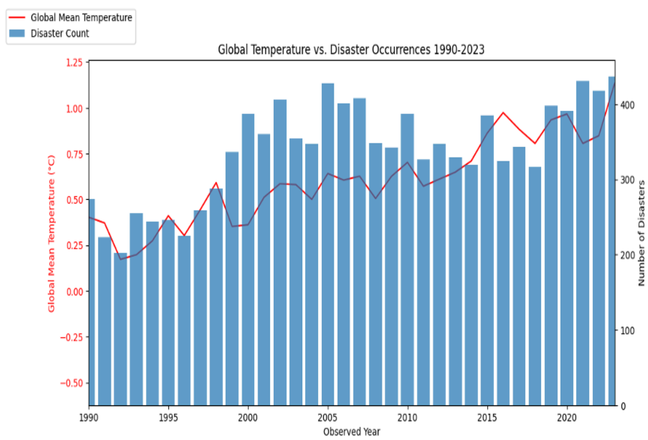
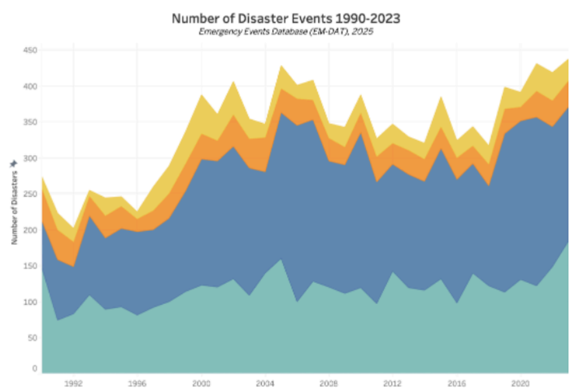
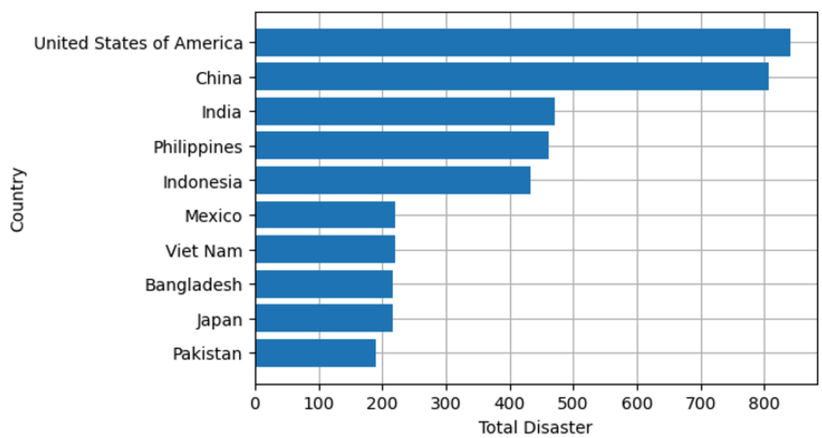


Figure 9: Global Disaster Categories from 1990 to 2023



3.4 The Burden of Natural Disasters in Developing Countries: While the rise in natural disasters affects the world, it is mostly developing countries like India, Philippines, and Indonesia, often the least responsible for carbon emissions, that bear the brunt of these disasters. Although these countries are in regions more prone to extreme weather, the frequency of these disasters is increased due to the rise of carbon emissions, which is mostly driven by far more developed countries, implying a disproportionate impact on developing countries. The consequences become more severe in these countries because they lack the infrastructure and resources to withstand these events, thus deepening their poverty and social instability. In 2023, India faced devastating floods in Himachal Pradesh and Uttarakhand due to intense monsoon rains. Flash floods and landslides displaced thousands, damaged infrastructure, and killed over 100 people. The disaster caused significant agricultural losses, exacerbating challenges for these vulnerable regions already struggling with poverty.

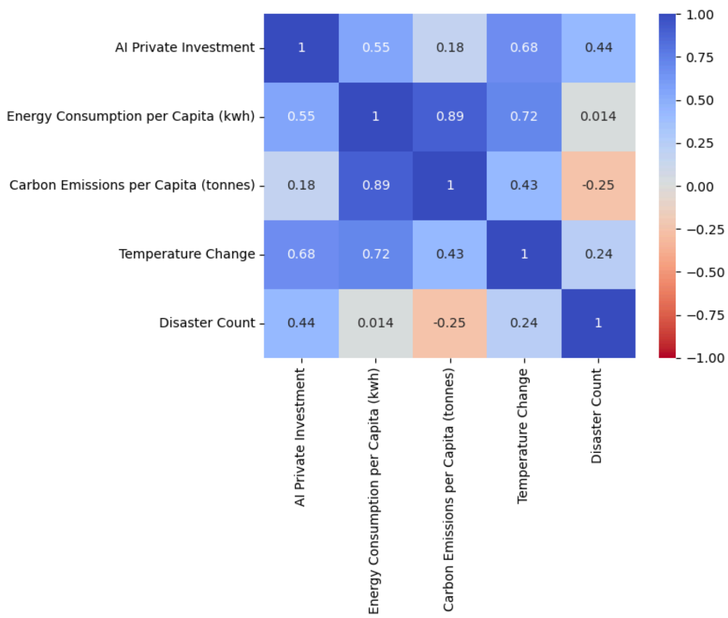
Figure 10: Global Disaster Occurrences from 1990 to 2023



4. Conclusion

4.1 Correlation Between AI Investment, Energy, & Climate Variables: The correlation matrix in Figure 11 reveals a positive relationship between AI investment and key environmental factors like energy consumption (0.55), carbon emissions (0.18), temperature change (0.68), and disaster frequency (0.44). Stronger correlations exist between AI and energy, temperature change, and disaster, while the weaker link with carbon emissions may reflect a shift toward renewable energy. Energy consumption is strongly correlated with carbon emissions (0.89), while the correlation between temperature change and disaster frequency is relatively weak. This suggests that while rising temperatures are a contributing factor, other variables also play a significant role in the occurrence of natural disasters. While the data supports the hypothesis that AI investment aligns with rising energy use and climate change, it does not establish causation due to potential missing variables.

Figure 11: Correlation Matrix



4.2 AI Investment and its Environmental Impact: Our analysis reveals a noticeable relationship between AI investment, energy consumption, carbon emissions, and climate change. The rapid AI expansion is particularly funded by countries like the United States, China, India, the United Kingdom, and Canada. As AI investment grows, energy consumption and per capita carbon emissions continue to rise globally, contributing to environmental challenges. Our analysis reveals a correlation between AI investment and rising environmental challenges, particularly in regions most vulnerable to climate-related disasters. Thus, as AI advancements continue to grow exponentially, we believe countries will need to significantly intensify their efforts to address the negative climate impacts in order to preserve and protect our environment for the future.

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