Data Ecofeminism

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Abstract

Generative Artificial Intelligence (GenAI) is driving significant environmental impacts. The rapid development and deployment of larger algorithmic models consumes substantially more energy than traditional models, contributing to rising carbon emissions, water withdrawal, and e-waste generation. To mitigate these impacts, big tech companies are developing different strategies such as turning to nuclear energy to meet the demand for GenAI electricity and avoid carbon emissions, an approach that could have profound social and environmental implications beyond carbon reduction.

This paper proposes a critical rethinking of GenAI's proliferation through an ecofeminist framing, which has historically interrogated the role of science and technology in the context of gender and environmental justice. To do so, it introduces seven data ecofeminist principles delineating a pathway for developing technological and just transition alternatives within the AI research context, emphasising a critical examination of this technology's role in the current socio-ecological crisis. The paper calls for an urgent reassessment of the GenAI innovation race, advocating for ecological and feminist technological projects that prioritise and respect life, people, and the planet.

CCS Concepts

• **Computing methodologies → Artificial intelligence**; • **Hardware → Impact on the environment**.

Keywords

Ecofeminism, Artificial Intelligence, Sustainability, Critical Data Studies, Data Feminism

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1 Introduction

In 1979, twelve women came together to organise a meeting focused on the relationship between women and ecology, prompted by one of the worst nuclear accidents in history: the partial meltdown at the Three Mile Island nuclear plant in Pennsylvania, United States (US). The incident resulted in the release of radioactive gases from Unit 2, one of the plant's reactors. In response, local authorities evacuated 150,000 residents, including pregnant women and children, and ordered the closure of schools. Motivated by these events, these women formed the group called *Women and Life on Earth*. They issued a statement in 1979 calling for a reimagined society founded on ecological principles to prevent the threat of another nuclear disaster. One year later, in March 1980, they organised the first conference on ecofeminism in the US. The event drew over 600 women who engaged in discussions on ecological feminism, peace, and alternative energy solutions. This conference is widely recognised as the moment when the term *ecofeminism* was first introduced in the US, creating a vital intersection between environmentalism and feminism [88].

Forty-five years later, in 2024, Microsoft announced plans to reopen one of the reactors at the Three Mile Island nuclear power station, the same site that originally sparked the ecofeminist movement in the US [10]. This intersection of events provides an opportunity to revisit ecofeminist debates in the context of the contemporary race for innovation in Artificial Intelligence (AI). Within this race, in the last decade, Generative AI (GenAI) and its rapidly growing industry require vast amounts of energy to support the immense computational power needed for model training. GenAI models are built on larger algorithmic architectures, such as neural networks and stable diffusion techniques, which process large datasets to identify patterns and regenerate outputs like images, text, or videos. This computational power is translated into increased energy consumption by the GenAI industry. In fact, the energy demands of GenAI contribute significantly to its industry's carbon emissions [54, 87]. These emissions are exacerbated when the power grid supporting the data centres where GenAI models are trained relies on fossil fuels, raising concerns about the tech industry's ability to meet its net-zero commitments. Microsoft, for example, has pledged to eliminate its reliance on diesel fuel by 2030. To achieve this goal, the company has invested in nuclear energy, as exemplified by its plans for the Three Mile Island plant. Nuclear energy offers a means of reducing dependency on fossil fuels, yet it comes with other environmental risks such as the generation of radioactive waste and potential catastrophic accidents.

Beyond carbon emissions, GenAI has additional environmental impacts, including water consumption and waste generation. The GenAI industry relies on vast quantities of potable water to cool down chips used in the training phase of algorithmic models. For

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instance, the Large Language Model (LLM) LLaMA-3, developed by Meta, consumed 22 million litres of water over a 97-day period [78]. To put this into perspective, this is equivalent to the amount of water an average person in England and Wales would use over the course of 424 years.[1] E-waste represents another significant environmental issue associated with this technology. The electronic waste generated by LLMs is estimated to increase substantially in the coming years, 5.7 million tonnes between 2023 and 2030 [141]. The environmental impacts of e-waste are primarily linked to its toxic components, such as lead and mercury, which have the potential to contaminate water and soil and pose serious environmental and health consequences to humans and non-humans. The burgeoning literature on this topic has critically emphasised the importance of uncovering the environmental impacts of this technology in the context of the ongoing climate emergency and has also raised doubts of how it could be used as a tool to tackle the consequences of climate change [15, 145].

Within this context, this paper proposes seven principles for *Data Ecofeminism*, aiming to provide critical reflections on how data and AI technologies can be developed for alternative eco-social transformations. Given the expanding environmental footprint of the GenAI industry, these principles offer a theoretical and empirical framework that examines the crossroads of intersectional feminism, AI, and environmental issues to promote social and environmental justice. Building on *Data Feminism* [35] and digital feminism manifestos [50], the proposed principles draw upon ecofeminist, decolonial, and Science and Technology Studies (STS) literature, which have historically traced the connections between science, technology, and discriminatory mechanisms. The principles acknowledge that global warming is largely driven by large corporations and wealthy states based in the Global North, with big tech companies exacerbating the socio-ecological crisis by, for instance, collaborating with the fossil fuel industry. Data Ecofeminism seeks to illuminate the material realities of AI and its supply chains, advocating for transparency and accountability regarding AI sustainability. It calls for integrating a degrowth perspective through approaches such as frugal computing or permacomputing, promoting smaller models that perform as effectively as larger ones. The principles also emphasise the importance of digital sovereignty by advocating for autonomous and local infrastructure to meet our digital needs sustainably. Data Ecofeminism supports the preservation of physical and digital commons through mutual aid and collective stewardship. And, last but not least, it embraces pluriversal epistemologies, drawing on past and present cosmovisions and their relational understanding of our planet.

2 Background

2.1 What is ecofeminism?

Ecofeminism is a movement situated at the intersection of environmentalism and feminism [43, 61, 126]. It seeks to explore the interactions and potential synergies between the protection of ecosystems and natural resources and the challenges arising from gender inequality. As Vandana Shiva describes it, ecofeminism represents a 'new term of ancient wisdom' that 'grew out of various social movements—the feminist, peace and the ecology movements' [88]. Ecofeminism bridges the gap between environmental, racial, and gender justice by articulating theories and practices that interrogate ideologies that 'authorises oppressions based on race, class, gender, sexuality, physical abilities, and species', while, at the same time also sanctioning 'the oppression of nature' [48, p. 1]. And in fact, Shiva observed an ideological and material connection between the oppression of women and nature [1]. However, this connection has not always been evident. While the term ecofeminism was first introduced in Françoise d'Eaubonne's book *Feminism or Death* (1974) [34], her work was initially met with significant criticism from the French academic community, as they considered women and nature unrelated concepts [105]. Despite this early resistance, her work is now recognised as foundational to the first wave of the ecofeminist movement in the 1970s.

Ecofeminism has often been regarded as a predominantly white, Western movement [72, 113], but it has increasingly incorporated decolonial perspectives, drawing on contributions from scholars who examine intersections of feminism, environmental justice, and racial and colonial legacies [2, 32, 42, 43, 53, 58]. Vandana Shiva critiqued US ecofeminists for overlooking the intersections of Western colonialism, gender oppression, and environmental degradation in the Global South [118]. Bina Agarwal also challenged Western ecofeminism, arguing that it remains a 'critique without threat to the established order' [1, p. 153] and called for analyses grounded in Global South perspectives [8]. Agarwal further criticised ecofeminism for treating women' as a homogeneous category, failing to account for differences of class, race, and ethnicity [1, p. 122]. Decolonial feminism has raised significant critiques of ecofeminism, emphasising the need to acknowledge the history of colonisation in processes of environmental degradation. For instance, Françoise Vergès, in *A Decolonial Feminism*, calls for a feminism that recognises the legacies of European colonialism and racism, highlighting how racialised women disproportionately bear the burden of managing the waste created by capitalism and extractivism [138]. This is evident, as Vergès points out, in examining who cleans train stations in major European cities. In the specific case of AI, this becomes evident when examining who extracts the minerals for electronics, manufactures GPUs, or manages the e-waste generated by AI hardware: usually racialised and historically marginalised subjects whose labour and struggles have been invisibilised [93, 134, 142].

2.2 The relationship between ecofeminism, science and technology

STS have provided crucial scholarly insights into the connection between ecofeminism and technology [48, 59, 71, 88, 113], although it has not been always straightforward. As Julia E. Romberger aptly argued in one of the few works addressing the link between ecofeminism and digital technologies: 'ecofeminism calls for critical examination of the appropriateness of technology' [112, p. 121]. That said, ecofeminism should not be seen as an anti-technology movement. Instead, it should be recognised as a philosophical, theoretical, empirical, and political praxis that: (1) recuperates science and technology from feminist, decolonial, and environmental perspectives [113], (2) challenges any logic of domination, capitalist modes of production, and the hegemony of mechanistic science [59];

[1] According to Statista [120], one person in England and Wales uses about 142 L of water per day.

and, (3) considers heterogeneous perspectives from those historically marginalised, with the aim to 'build a world of many worlds where everybody fits' [31, 114].

Ecofeminism has historically criticised technocratic approaches [13] and technologies that threaten life on Earth [88, 119]. Since Carson's *Silent Spring* (1962) [18] demonstrated the environmental harms caused by pesticides used by soldiers during WWII, ecofeminists have challenged the illusion of rational and objective technology. They have shown how technological artifacts are shaped by Western, capitalist, and masculine values, which are used to dominate both nature and women's bodies [21]. In this vein, Haraway also argued in *Simians, Cyborgs, and Women* (1991) that after WWII, 'electronic industries and communications technology were increasingly tied to strategies of social and military planning' [59, p. 58]. These ecofeminist criticisms have also focused on production, reproductive, and domestic technologies [139] as well as militarist and nuclear technologies [13]. More recently, ecofeminists in Latin America have questioned sustainable development technologies, such as green energy projects, arguing that they also contribute to environmental harms and serve as a rationale for reproducing capitalist activities [69, 102]. However, little attention has been given to the connection between ecofeminism and data and AI technologies. Given the increasing environmental footprint of GenAI technologies and their associated industries, this paper proposes an ecofeminist approach to data and AI technologies by contributing to critical AI literature and opening a dialogue between ecofeminism and GenAI technologies.

3 Related work

3.1 On the environmental impacts of AI technologies

In recent decades, AI has been promoted as a key tool for tackling climate change [22, 25], with claims such as 'AI is essential for solving the climate crisis' [83]. Yet, critical analyses of the environmental costs have raised doubts about the sustainability of AI [15, 36, 145]. Recent developments in GenAI are considered computationally intensive, meaning they require vast amounts of energy and water to train algorithmic systems.[2] If this energy comes from burning fossil fuels, training algorithmic systems results in carbon emissions, which is widely recognised as an environmental impact [66, 81]. Academics, activists, policy-makers and journalists have raised significant concerns about the benefits of AI technologies in addressing climate change, due to their computational costs and the resulting environmental impacts. Google, Meta, and Microsoft have acknowledged in their annual sustainability reports that GenAI technologies are driving up their environmental impacts [15, 16, 27, 65, 74, 77, 123]. As a result, the growing literature on the environmental effects of GenAI has shown that, rather than being a solution to climate change, this technology is contributing to it.

Scholars Emily Bender et al. (2021) were pioneers in raising awareness about the environmental harms of LLMs in their influential work, on *Stochastic Parrots* [11]. As a result, critical AI scholarship has increasingly focused not only on the social and technical dimensions of AI but also on its environmental impacts [106]. Taxonomies of algorithmic harms are now incorporating environmental costs as part of the risks associated with AI implementation, such as carbon emissions [81] and water usage [37, 74]. As this body of work also demonstrates, examining the infrastructure of GenAI technology reveals harms that data centres pose not only to the environment but also to local communities. For example, media scholar Mél Hogan (2015) highlighted that data centres in the US extract large amounts of water [65], while Libertson et al. (2021) and Bresnihan and Brodie (2021) [14, 79] criticised the substantial energy demands of the data centre industry, which disrupts energy access and has led to electricity grid collapses in local communities in Sweden and Ireland. Furthermore, other critical scholars have argued that the environmental harms of AI should be considered across the entire commodity chain, rather than focusing solely on data centres [134]. Examining other industrial activities crucial to AI development, such as mineral extraction, chip manufacturing, and e-waste dumping, uncovers additional environmental harms [128]. These perspectives suggest that attention to the environmental harms of AI should also be drawn to other issues, such as soil degradation and the waste generated by the AI industry.

3.2 An ecofeminist approach towards AI

Feminism and AI are two interconnected concepts that have been widely analysed, but what about ecofeminism and AI? While there have been numerous studies highlighting the need to incorporate feminist perspectives into AI, reflections from an ecofeminist standpoint remain unexplored in the critical AI literature. As an example, the *Data Feminism* framework proposed by scholars D'Ignazio and Klein (2020) [35] draws on seven principles to expose how feminism can rebalance power in AI/ML research, including challenging power, embracing pluralism, considering context, and making labour visible, among others. However, three years after their book was published, they revisited these principles, emphasising the importance of analysing the environmental issues posed by AI development and deployment, which should be integrated into data feminist approaches [73]. This paper is intended to take this invitation revisiting AI critical feminist perspectives by integrating environmentalism.

An ecofeminist perspective on AI must acknowledge the hegemony of Western science and technology that has been dominated by White males, as scholar Kate Crawford pointed out [26]. This ecofeminist value has been crucial in critical AI and STS scholarship, such as the work of Judy Wajcman, Ruha Benjamin, Timnit Gebru, and Donna Haraway, who have shed light on how technological artifacts embody white and masculine supremacism [12, 51, 59, 139]. For instance, in the early 90s, Haraway introduced the concept of *situated knowledge* that challenged scientific objectivity and visualising technologies that are tied to 'militarism, capitalism, colonialism, and male supremacy' [59, p. 188]. And in fact, Haraway highlighted how science is historically linked to militarism:

> War and problems of military management encouraged new developments in science [...]. Operations research began with the Second World War and efforts to co-ordinate radar devices [...]. Statistical models

[2]The electronic circuits used to train GenAI, such as GPUs, NPUs, and TPUs, require more electricity than circuits used in previous models. Increased electricity consumption also translates into higher water usage to cool down these chips.

were increasingly applied to problems of simulation and prediction for making key decisions. [59, p. 58]

AI, which theoretical grounds are partially rooted in Operational research and statistics, is not an exception and this technology is nowadays used in the military-industrial complex [70, 131]. For instance, OpenAI has announced contracts to deploy AI in the battlefield [108]. Given the large historical tradition of ecofeminist movements being mobilised against war [49], an ecofeminist position towards AI should confront its weaponisation for the destruction of life and reject any technology used in armed conflicts. This has been made explicit by ecofeminist Yayo Herrero, who criticised the use of AI in military operations in a conversation about the future of ecofeminism with Vandana Shiva in Barcelona (Spain). Herrero emphasised that through the AI complex industry, we are witnessing a 'new wrinkle in a technology of death and war, which is able to detect whose life is dispensable' [119]. This ecofeminist referred to *Lavender*, a Machine Learning (ML)-based algorithmic system implemented by the Israeli army to identify and kill individuals allegedly linked to Hamas [82]. With a 10% error rate, this system was deployed to target missiles at individuals previously detected by the algorithm, which could result in the deaths of innocent people. This algorithm directly moves against ecofeminist values, which prioritise the value of all life, human or non-human, on Earth and challenges any organised social form of domination and hierarchy.

In general, an ecofeminist approach towards AI should acknowledge the connection between gender, racial, environmental, and other historical struggles reproduced by data and AI technologies. While it is widely known by the FAccT community that datafication reproduces oppression mechanisms such as the racialisation of subjectivity [12, 135], sexism [140] and transphobia [3], recent literature has shown how these mechanisms are intertwined with environmental struggles [134]. For a long time, the literature on algorithmic violence has neglected AI environmental consequences and the commodification of resources that this technology involves. This technology, which continues to reproduce existing socio-technical inequalities, is also contributing to climate change by exacerbating environmental impacts. In contrast, Latin American media scholar Paola Ricaurte (2019) illustrated how nature is another dimension of oppression in the epistemology of data [109], arguing that the process of datafication extracts land and resources from communities, damaging our relationship with nature. Therefore, following ecofeminist reflections, this approach should consider the material reality of AI and how nature is subjugated to extract natural resources and burn fossil fuels for developing this technology nowadays.

4 Data Ecofeminism

The seven principles for *Data Ecofeminism* emerge from the need to establish guidelines, particularly in the context of GenAI technologies, that align with intersectional and decolonial feminism, while remaining critically aware of the environmental degradation and commodification of nature that making AI entails. This ecofeminism framework is proposed to guide the development of digital data technologies and algorithmic systems that challenge technological power and any form of domination and hierarchy, redirect it, and help build a thriving society within a living, caring world where everyone, human or non-human, can fit.

4.1 Principle 1: Examine power structures within the climate crisis

Data Ecofeminism recognises that wealthy countries are significant contributors to global warming.

According to the IPCC (2022) [68], it is unquestionable that human and capitalist activities have warmed the atmosphere, contributing to global warming and increasingly extreme weather events and natural disasters. Capitalist societies have accelerated the climate crisis by accumulating capital through the extraction of resources that commodify nature. However, asymmetric and unequal power relations emerge in this context, giving rise to environmental injustice. High-income countries bear a substantially higher degree of responsibility for climate change, while low-income countries suffer disproportionately more from its natural disasters, despite not contributing to it [99]. While the Global North was responsible for 92% of excess global CO_2 emissions [63], more than 91% of deaths caused by climate change occurred in the Global Majority [133]. The US and EU-28 countries are at least twice as responsible as China or India, given their historical contributions to carbon emissions. But it is not only about carbon emissions; a recent publication in *Nature Sustainability* illustrated that minerals and metals essential for manufacturing electronics are primarily extracted from Indigenous and peasant lands [98]. In fact, the political and power structures in the context of climate change are entangled in a colonial and racial legacy that imposed its capitalist rationality around the world [46, 64].

Given these disparities, ecofeminist movements have called for the politicisation of the climate crisis by understanding how power structures within capitalism are orchestrated [62]. In the words of the decolonial feminist and scholar Françoise Vergès: 'global warming and its consequences for the peoples of the South is a political question and must be understood outside the limits of "climate change" and in the context of racial capital' [137, p. 7]. Therefore, being aware of climate change and environmental injustices also encompasses comprehending different vectors of struggle, such as class, gender, race, and nationality, among others, and analyse these vectors from an intersectional standpoint.

Within this context, the AI industry has been governed by white and male elites whose Western, colonial and capitalist ideologies have also been embedded within algorithmic models [26, 70]. Digital data is a crucial factor in the development of AI and GenAI, and numerous studies have demonstrated how the big tech industry reproduces these ideologies—for instance, see Couldry and Mejías (2019) for *Data Colonialism* [24] or D'Ignazio and Klein (2020) for *Data Feminism* [35]. From an ecofeminist perspective, the AI industry is also contributing to climate change by courting major fossil fuel companies and offering AI-based products that facilitate extraction [36]. According to Greenpeace's report *Oil in the Cloud* (2020), Microsoft, Alphabet, and Amazon have contracts with the oil and gas industry to unlock oil and gas deposits using ML [55]. Another AI company, in this case, NVIDIA, is also partnering with Petrobras to explore new oil and gas extraction fields through AI [96].

Moreover, the carbon emissions of private jets used by big tech billionaire CEOs are also contributing to climate change:

> The two private jets owned by Jeff Bezos, founder and executive chairman of Amazon, collectively spent almost 25 days in the air, emitting 2,908 tonnes of CO_2. It would take the average US Amazon employee almost 207 years to emit that much. [100, p. 9]

Thus, a data ecofeminist approach calls for a critical examination of the economic and corporate male elites who instrumentalise their power in the AI industry to accumulate capital through natural resource exploitation. This approach considers that the AI industry, which is predominantly based in the Global North, is also contributing to global warming, in some cases even more than entire nations based in the Global Majority [44].

4.2 Principle 2: Consider digital materiality and its supply chains

Data Ecofeminism acknowledges that datasets and GenAI infrastructure are derived from natural resources, emphasising their supply chains, labour exploitation, and associated environmental impacts.

As media ecology scholar Sy Taffel claimed, attention should be drawn to the material aspects of the 'planetary-scale extractive industries' developed for the acquisition of digital data [128]. The cloud, also known as a data centre, is a concrete infrastructure, that contains servers stored in rooms that process data and allow Internet connections [67]. Over the last decade, the number of data centres has drastically increased to power the digitalisation of our daily lives and motivated by economic growth. This industry is becoming one of the most profitable in the digital economy [16, 17, 29, 76], but its economic activity has a massive environmental footprint [143].

Narratives about the so-called cloud do not only obfuscate its materiality [89], but also its environmental impacts [33]. Most data centres use fossil fuels, such as gas, oil, or coal, to power their servers, which contributes to a surge in carbon emissions by big tech companies [54, 87]. Data centres also require vast amounts of water to cool down server rooms, causing struggles in local communities [16, 77]. In some cases, the data centre industry uses vast amounts of water in regions suffering severe droughts, where local communities do not even have access to drinking water in their own houses [134].

The increasing size of GenAI models is transforming the AI industrial complex and its economic value. In only 5 years, the size of models has increased by 15,000 times [7], which is translated in the extraction of more resources for algorithmic training. GenAI technologies need to be trained in data centres where GPUs operate, which is accelerating the construction of more data centres. This acceleration is in turn demanding for more chips, that are in turn demanding for more minerals [107]. Thus, there is a need to draw attention to AI/GenAI supply chains which are 'the orchestration of commodity chains that extract, ship, and manufacture the natural resources needed to develop AI from an infrastructural perspective, such as mines, data centres and e-waste dumps together with their human resources' [134, p. 5]. Within these supply chains, the firm that provides GPUs worldwide, NVIDIA, has ranked third in the list of market capitalisation, surpassing other big tech companies such as Amazon, Meta or Alphabet [122]. With an increase in its market value, this suggests that NVIDIA is interested in supplying more chips for its own economic growth. However, this also entails other environmental impacts. It is estimated that the energy used by NVIDIA's chips in 2024 is greater than the energy used by Georgia, Guatemala or Costa Rica [19]. Within this supply chain, the Taiwanese firm, TSMC, which is the semiconductor firm that manufactures and provides chips to NVIDIA, is becoming a key actor within the AI industry providing almost the 80% of chips used for AI training. In fact, TSMC has risen to the ninth position in the market value ranking [122]. Given the importance that this semiconductor factory has gained in the global economy, the Taiwanese government notified to rice farmers that water should be prioritised to TSMC during a drought episode [131].

One important aspect of these supply chains is also labour exploitation. Critical scholars and journalists have unveiled how AI relies heavily on underpaid human labour in the Global South and historically marginalised communities that label datasets [92, 144]. But, unfortunately, others scholars have also pointed out at how labour exploitation extends beyond AI training and is also present in the making of AI chips with migrant labour forces assembling GPUs in Taiwan [142]. A data ecofeminist approach considers the material dependency of digital technologies and the ecological harms and social impacts that emerge across these commodity chains.

4.3 Principle 3: Make visible and accountable AI environmental impacts

Data Ecofeminism proposes to make accessible and publicly available environmental metrics and effectively reduce them.

In 2020, The Register published a report claiming that ChatGPT's foundational model, GPT-3, had the same carbon footprint as a 700,000 km car trip, which is twice the distance between the Earth and the Moon. An interesting aspect of this report was the quantification of algorithmic carbon emissions. For instance, while a classic model is estimated to emit 78,468 lbs of CO_2, a transformer model is estimated to emit 626,155 lbs [125]. GenAI systems require more computing power than classic ML algorithms because they can handle more data and perform more complex calculations compared to their algorithmic predecessors. More recently, Luccioni, Viguier, and Ligozat (2023) estimated the carbon footprint of a 176-billion parameter language model, which emitted approximately 50 tonnes of CO_2 taking into account manufacturing and training activities [81]. But, what are the carbon emissions of GenAI technologies when we consider the entire supply chain, from mineral extractivism to e-waste dumping?

While Principle 2 proposes considering the materiality and supply chains of AI/GenAI technologies, Principle 3 advocates for making the environmental metrics associated with this process accessible, accountable and publicly available. Most big tech companies report their environmental metrics annually through Corporate Sustainability Reports (CSR). These documents are considered one of the few public sources of information that report environmental metrics associated with AI technologies. Within these reports, one can account for data centre's sustainability across different geographies. For instance, Alphabet's CSR illustrates that its data centres are generally more sustainable in the Global North, meaning that

Global Majority states are more exposed to the environmental costs of GenAI infrastructure [54].

Yet, these documents do not offer a detailed estimation of the carbon footprint of activities associated to AI, such as extracting minerals, manufacturing chips, building and operating data centres, executing algorithms, generating and gathering data, storing datasets, and finally dumping electronics. All of these activities entail carbon emissions and should be taken into account when estimating carbon emissions. But given that these activities are developed by other firms, it is a challenge to account for total carbon emissions because firms do not hold their providers and suppliers accountable [124]. For instance, while NVIDIA also publishes their carbon emissions annually in the CSRs, there is a lack of detailed information on the carbon emissions from mineral extraction to manufacture their GPUs.

In this context, the European Parliament and the European Commission have introduced two pieces of legislation to make environmental information more accessible. On one hand, the Energy Efficiency Directive 2023/1791 (2023) stipulates that '[t]he Commission shall establish a European database on data centres that includes information communicated by the obligated data centres. The European database shall be publicly available on an aggregated level' [130]. This regulation was enforced in May 2024, but was delayed to September 2024. However, following a Freedom of Information (FOI) petition, the European Commission replied to me that this database is not publicly available yet. On the other hand, the Corporate Sustainability Directive 2024/1760 (2024), also known as the Supply Chain Act, establishes core elements to address adverse human rights and environmental impacts in a company's own operations, its subsidiaries, and, where related to their value chains, those of their business partners [129]. Among other obligations, this legislation requires companies to reduce greenhouse gas emissions across their entire supply chain to combat climate change.

Apart from carbon emissions, there are other environmental metrics that should also be made publicly available within the GenAI industry, such as water withdrawal and discharge or waste generation. The environmental costs of GenAI technologies are not limited to carbon emissions, but also include intensive water withdrawn by data centres or chip factories and soil contamination derived from e-waste dumping. This has been remarked by scholars Kneese and Young (2024) claiming that 'one problem with only considering the carbon emissions associated with LLMs and ignoring other environmental impacts is that optimizing for reducing the carbon emissions of training a model may actually exacerbate the water cost' [74]. A data ecofeminist approach calls for making all these metrics publicly available so that companies can be held accountable and systematically reduce their environmental metrics, thereby helping to limit global warming to 1.5°C (if it is still possible)[3] in line with the Paris Agreement [132] and respecting planetary boundaries, as well as labour, environmental, and other fundamental rights.

4.4 Principle 4: Prioritise frugal AI computing

Data Ecofeminism adopts a degrowth perspective towards data and AI technologies by using less energy, resources, and materials.

Data and GenAI is accelerating growth driving up big tech's environmental footprint [86]. According to Statista, in 2024 the world generated 149 zettabytes of data, and it is projected to generate 394 zettabytes by 2028 [121]. The generation and consumption of data contributes to increase energy demand: the more data that is generated, the more energy is used. At the same time, this data is also used to feed GenAI models that also contribute to this energy demand. As a result, Microsoft increased its carbon emissions by 40% during the 2020-2023 period due to ChatGPT and Copilot, Meta saw a 65% increase in emissions from 2021 to 2023, and Alphabet reported a 50% higher carbon footprint in 2023 compared to 2019, attributing this 'due to increasing energy demands from the greater intensity of AI compute' [23]. GenAI is also poised to drive 160% increase in data centre power demand [52]. As an example, Amazon has announced that their three data centres in Aragón (Spain) are going to use more energy than the entire region [84]. And water, it is estimated that the AI industry is going to take between 4.2 and 6.6 billion cubic meters of fresh water [78], approximately 4- and 6-times Denmark's water withdrawal. GenAI is also requiring more raw materials [101]: GPUs are nowadays using more chemical elements than chip predecessors in the 80s [90]. And waste, GenAI is also generating more e-waste and could increase 1000 times electronic residues, from 2,600 tonnes in 2023 to 0.4-2.5 million tonnes in 2030 [141]. This growth in energy, water withdrawal, carbon emissions, materials extracted, and e-waste generated is clearly impacting on climate change and planetary boundaries. Therefore, this data ecofeminist framework proposes to embrace a degrowth perspective towards computing to mitigate environmental impact driven by economic and technological growth.

Degrowth is defined by scholar Jason Hickel as a 'planned reduction of excess energy and resource use to bring the economy back into balance with the living world in a safe, just and equitable way' [64, p. 29]. Hickel together with other degrowth scholars based in the Global North such as Alice Mah, Serge Latouche, Carlos Taibo and Giorgios Kallis propose that degrowth is the only alternative to mitigate climate change, empower environmental justice and create a sustainable future. But how is a degrowth perspective translated into the data and GenAI context? In computing, digital degrowth is recognised as a form of sustainable computing [117] and has introduced the concept of frugal computing, which aims to 'reduce emissions from computing by using less energy and less materials' [136, p. 4]. Within this scenario, there is also the interesting perspective of permacomputing [60, 127] that 'asks the question whether we can rethink computing in the same way as permaculture rethinks agriculture' [91]. A degrowth and frugal perspective towards computing challenges the ever-expanding resource and energy use of data and GenAI technologies while questioning the desirability of algorithmic products.

Concretely, from a software perspective, it implies using small models than performs similarly to larger models [20], building models with a smaller number of features and hyperparameters without compromising performance [94] and storing less data. From a hardware perspective, it entails manufacturing more durable chips, strengthening the sustainability and efficiency of data centres whilst moderating the number of new facilities, and reducing e-waste generation, among other measures [17]. An ecofeminist approach towards AI challenges the construction of more sustainable

[3]Global warming has exceed 1.5°C during 2024.

data centres due to the Jevon's Paradox: the construction of more energy efficient data centres increases rather than reduce energy consumption. Another crucial aspect within the degrowth scenario is the *Right to Repair*, a global movement that aims at extending lifespan of products to reduce waste. In the context of AI, whilst it is estimated that a GPU has an average lifespan of 5 years [134], which dramatically contributes to the global electronic waste challenge, a degrowth perspective calls for extending this lifespan and allowing GPU users to repair their electronics.

4.5 Principle 5: Reclaim digital sovereignty

Data Ecofeminism calls for a public-led digital infrastructure.

In 1991, Donna Haraway observed that 'the new technologies seem deeply involved in the forms of "privatization" [...] in which militarization, right-wing family ideologies and policies, and intensified definitions of corporate (and state) property as private synergistically interact' [59, p. 168]. Thirty-four years later, in 2025, this same observation applies to big tech companies, given their political and economic dominance in the AI sector and the companies that control it. Alphabet, Meta, Microsoft, and Amazon account for 65% of global Internet traffic [115], much of which traverses their owned subsea cables—now comprising 71% of the total, a substantial rise from just 10% a decade ago [6]. These companies are also estimated to control a significant share of global datasets, which are essential for training their AI-based models. They develop and maintain digital platforms, such as email services and data storage, which both governmental and non-governmental actors heavily rely on. For instance, UK universities use Microsoft cloud and email services, while UK government departments and public bodies depend on Google's email services and Amazon's cloud storage. This dominance has positioned big tech firms at the forefront of the AI innovation race, with the latest GenAI models being developed primarily by the private sector rather than public universities.

Given the infrastructural, economic, and political influence big tech companies are accumulating, there have been calls for digital sovereignty. This concept refers to government's ability to act independently by taking 'autonomous actions and decisions regarding their digital infrastructures and technology deployment' [104, p. 8]. A recent policy paper on digital sovereignty proposed a 'progressive reform agenda to enhance digital sovereignty for people and the planet' [111, p. 2]. This agenda is built on four measures: offering a democratic and public digital infrastructure, designing a research agenda that is not driven by technological hype and solutionist narratives, promoting a public knowledge network that challenges profit- and control-motivated models, and expanding human and civil rights. A key aspect of this proposal, aligned with an ecofeminist approach, is its emphasis on prioritising life over market profit. In other words, it places people, the planet, and democracy above private economic gains. For example, during a severe drought scenario, the data ecofeminist approach would prioritise water resources for essential activities that ensure life for human and non-humans.

Building on digital sovereignty frameworks, a data ecofeminist approach envisions the creation of a public-led digital infrastructure that addresses people's essential digital needs while minimising environmental impacts. This vision emphasises the need to build a public cloud that eliminates dependency on private, profit-driven providers, thereby shifting the focus from economic gain to public welfare. It also advocates for the development of technological solutions that prioritise the well-being of people and the planet. A key aspect of this approach is dismantling practices of illegal data extraction and labour exploitation within the digital ecosystem. For instance, concerns have been raised about LLMs being trained on copyrighted materials, infringing upon the rights of writers and artists, and potentially undermining their livelihoods [38]. To align with an ecofeminist framework, digital sovereignty must adhere to legal and ethical standards, actively working to avoid perpetuating or reconfiguring existing social and labour injustices. This approach also necessitates a critical evaluation of which AI products are truly essential to develop, particularly in the context of the climate crisis. Ensuring that technological innovation explicitly aligns with ecofeminist principles of care, justice, and environmental sustainability is fundamental for building an inclusive and equitable digital future.

4.6 Principle 6: Foster the commons through mutual aid

Data Ecofeminism reclaims the communality in the digital era.

Communality refers to a shared sense of mutual aid [75], rooted in common interests and goals. It is supported by practices and services grounded in the values of reciprocity, participatory democracy, sustainability, and activities that prioritise life, people, and the planet [9]. Communality thrives through the commons, defined as cultural and natural resources that are collectively accessible and held in trust for mutual aid and social reproductive activities. Proposed as a strategy to mitigate the consequences of the climate crisis [9], communality ensures access to food and other basic needs [42] in a sustainable way [41] while fostering mutual aid during crises. For example, during the flash floods in Valencia (Spain) in October 2024 caused by unusually warm Mediterranean waters linked to global warming, mutual aid among citizens played a crucial role in addressing the immediate consequences. Despite the tragedy of 227 deaths, community efforts were instrumental in mitigating the impact of the disaster in its early days [30]. Historically, the commons were vital to survival, particularly in Europe during the late Middle Ages, where pastures, forests, and rivers were shared by peasants to grow crops and access water to sustain their communities [64, p. 46]. Scholars have noted that the first phase of capitalist development was marked by the dispossession and privatisation of the commons [4, 75, 88]. But how can the concept of communality and the commons be reimagined in the digital sphere through ecofeminist lens?

Ecofeminism and the commons are deeply interconnected, as women and historically marginalised communities have played a central role in defending their territories and asserting their 'right to land' [42]. Similarly, the Internet, originally conceived as a public resource, has been increasingly appropriated by the predominantly male-dominated big tech sector. In response, digital feminist movements have emerged to reclaim and reimagine digital spaces. Decades ago, cyberfeminism emerged as a counterpoint to male-dominated visions of technology [103, 116]. Today, new forms of digital feminist communities continue to empower historically marginalised groups, focusing on care and community as core values [45].

The concept of digital commons, defined as 'digital resources that are commonly controlled by humans' [47, p. 19], offers a promising alternative for providing basic public services and fostering participatory democracy. Examples include public subsea cables, non-profit data centers, and free and open-source software [17], which can also be more sustainable than private ownership models [41]. While GenAI technologies and their associated industries drive an increasing consumption of energy, land, data, and water—resources often exploited for private interests, a data ecofeminist approach advocates the creation and reappropriation of both physical and digital commons. This perspective calls for a critical examination of GenAI's impact on communal resources [28], the protection of communal land against expropriation for profit-driven activities that do not benefit their communities, and the development of ecofeminist infrastructures that support life, people, and the planet [57]. A data ecofeminist framework envisions nurturing relational worlds of care both within and beyond the digital sphere. It advocates for the development of data and AI technologies that embrace mutual aid and prioritise tools essential to advance social and environmental justice, particularly in the face of the climate crisis. By reclaiming communality in the digital era, data ecofeminism seeks to build technologies that serve human and non-human life, rather than perpetuating exploitative systems of power dynamics and capitalist profit that destroys these lives.

4.7 Principle 7: Weave the pluriverse

Data Ecofeminism values different and diverse epistemologies to build a world where many worlds fit.

In *Azmapu* (2023), a piece written by Elisa Loncon, the author revisits the values of the Mapuche philosophy related to the care of the Earth [80]. One of the key points within this philosophy, which is also common in many other Indigenous philosophies, is the understanding that the world is interrelated, meaning that every element within it is connected. Loncon argues that the Mapuche philosophy does not consider natural resources as such, which is a Western and anthropocentric concept. Instead, this philosophy acknowledges all beings of nature and develops a reciprocal relationship to foster care and respect. In doing so, the Mapuches cultivate a connection with nature, fostering a deep commitment to protecting their lands and preserving their biodiversity from capitalist extractive projects [95]. This is also what the decolonial scholar Arturo Escobar has introduced as radical relationality: 'the fact that all entities that make up the world are so deeply interrelated that they have no intrinsic, separate existence by themselves' [40, p. xiii]. Escobar proposes that radical relationality emerges as a counterproject to modern and capitalist struggles for social and environmental justice. Yet, radical relationality and Native epistemologies are often dismissed by the hegemonic project of modernity, which is rooted in Enlightenment rationalism and Western science, and, as ecofeminists have criticised, it has historically been dominated by male-dominated cultural institutions that have devastated the planet [56].

The data ecofeminist approach aims to weave the *pluriverse*, or in other words, to embrace 'the heterogeneous worldlings coming together as a political ecology of practices' [31, p. 4], by acknowledging the radical relationality among human and non-human beings and the right of rivers, forests, and seas to be safe from capitalist and polluting activities. This aim is based on the fact that ecofeminism is considered a plural movement, where there are as many ecofeminisms as theories, points of views, and vital experiences, including Native cosmologies [48, 105]. Within the pluriverse, the data ecofeminist perspective proposes that Native epistemologies should have a relevant role as a reparation action given the historical discrimination that Native peoples have suffered in their efforts to protect their land and epistemologies against colonialism, evangelization, and Western-imposed development [39]. Moreover, *Data Ecofeminism* reconsiders AI impacts on the environment through radical relationality among human and non-human beings, seeing beyond natural resources, which embraces other historical and contemporary Native epistemologies, such as that of the Mapuches [39]. In other words, an ecofeminist relationship between AI and the environment should not only envision how GenAI technologies are damaging the environment through quantitative estimations of carbon emissions and water withdrawal measurements, but also acknowledge different perspectives and experiences of how natural elements are interconnected and seen as other beings rather than resources, holding their own rights to be protected and preserved.

5 Discussion

According to Foundation Capital, the advent of GenAI-powered models is transforming the service-as-software paradigm, whereby tasks previously performed by workers will be undertaken by LLM-based chatbots.[4] This transformation is evidenced by the significant number of organisations incorporating AI features, such as Wikipedia, Duolingo, Google, Overleaf, and others. Whilst economic elites remain optimistic about this paradigm, suggesting it could represent a USD 4.6 trillion opportunity, the consequences of the climate crisis continue to intensify. The Copernicus Climate Change Service observed that January 2025 was 1.75°C above pre-industrial levels, exceeding previous global temperature records. The planetary boundaries framework, which assesses various processes critical for maintaining Earth's stability and resilience, has determined that six of the nine boundaries have been transgressed, thereby placing our planet and life itself in jeopardy [110].

Within this context, AI is not only promoted as a tool for economic profit, but also a technology to tackle the consequences of the socio-ecological crisis. However, critical literature on AI's environmental impacts indicates otherwise, exposing how it is increasingly becoming part of this crisis. The environmental costs associated with this technology are rising, thus necessitating a reconsideration of whether AI-powered models could be designed as technology that respects life, people, and the planet.

Ecofeminist debates offer an opportunity to integrate eco-social perspectives for a just transition, guiding us towards a reflection on how we could develop environmentally sustainable AI models. This opportunity is presented through seven principles advocating for AI technologies developed from an ecofeminist standpoint [112].

[4]See 'AI leads a service-as-software paradigm shift': https://foundationcapital.com/ai-service-as-software/ (Last accessed May 05, 2025).

Principle	Ecofeminist Debate	FAccT Community Action	Policy Intervention
Principle 1: Examine power structures within the climate crisis	Global and decolonial ecofeminist voices on how the Global North and capitalist firms are the main contributors to the eco-social crisis [118, 138].	Demand that our institutions develop and implement effective mitigation plans regarding their environmental impacts and be aware of our own environmental footprint.	Promote effective democratic and sustainable AI governance and ecological internationalism [111].
Principle 2: Consider digital materiality and its supply chains	Ecofeminist perspectives towards the material dependency of science and technology [59, 62, 118].	Be aware of the extensive infrastructural elements and long-term environmental consequences related to AI. Evaluate trade-off between environmental costs and social benefits of AI.	Oblige companies to respect human rights and environmental protection in their supply chains (see the EU Supply Chain Directive [129]).
Principle 3: Make visible and accountable AI environmental impacts	Ecofeminist debates about the role of Western science and technology in destroying life and the planet (pesticides, nuclear energy, etc.) [62, 118].	Calculate and inform about the environmental impacts of our algorithmic systems [81]. For instance, use `carbontracker` [5] to account for algorithmic carbon emissions.	Establish international standards for environmental metrics reporting. Oblige companies to make their environmental metrics publicly available (see the EU Energy Efficiency Directive [130]).
Principle 4: Prioritise frugal AI computing	Ecofeminist degrowth as a path for 'sustaining life as a way to decenter capitalist markets both in economic analyses and in proposals for alternatives' [97, p. 224].	Study viability and performance of larger models compared to smaller ones [94] . Remove data when not necessary. Disconnect serves in data centres if they are not being used. Foster digital degrowth and permacomputing perspectives [60, 117].	Reinforce policies that priorities environmentally sustainable AI models, whilst also evaluating its utility and social benefit. Promote *Right to Repair* regulations.
Principle 5: Reclaim digital sovereignty	Privatisation of new technologies [59].	Train public AI models that are fostering fundamental and environmental rights in public-led infrastructure.	Offer a public-led digital stack [111].
Principle 6: Foster the commons through mutual aid	Politics of the common as 'communitarian property- and resource-management regime, that, at least partially, makes social reproduction independent from waged labour and responds to parameters of direct democracy' [97, p. 223].	Prioritise free software with open protocols. Promote mutual aid across our communities.	Protect common resources that benefit local communities.
Principle 7: Weave the pluriverse	Ecofeminism as a plural and diverse movement with different perspectives towards natural resources as elements with life to which we are interrelated [80].	Engage with interdisciplinary conversations on other types of knowledge and be aware of ecofeminist critiques of science and technology [109]. Foster critical thinking and challenge techno-hype.	Acknowledge Indigenous cosmovisions, treating Indigenous cultures and perspectives with dignity while fostering their autonomy. Support extending legal rights to natural entities such as rivers, mountains, insects, and other non-human beings.

Table 1: Relationship between Data Ecofeminism principles and ecofeminist debates, and how these principles could be applied by the FAccT community and policymakers.

Whilst these principles offer different dimensions of analysis integrated with ecofeminist values, they are interconnected.

Principles 1, 2 and 3 provide a framework that renders visible the environmental impacts of the AI industry by considering: who is contributing to climate change; what environmental costs are associated with AI across its supply chains; and how we can obtain public information about these costs. These three principles resonate with some Data Feminism principles [35]. Specifically, both approaches propose examining power relationships. Whilst Data Feminism's Principle 1 acknowledges the environmental costs of data centres, Data Ecofeminism's Principle 1 delves deeper by specifying that it concerns not only infrastructure, but also how big tech is connected to the fossil fuel industry, or how their CEOs emit more carbon in their lifetimes than their workers would in theirs.

These initial three principles are also associated with Principles 4, 5, and 6, which establish actions to build and operate AI models that place respect for life and care at their core. Whilst Principle 4 fosters a degrowth perspective towards AI, Principles 5 and 6 propose regaining sovereignty of infrastructure and prioritising communal resources over capital profit. For example, Principle 6 is also related to Principle 2, because remaining aware of the materiality of AI makes it obvious that its infrastructure requires resources that are typically extracted from Indigenous or peasant lands [98]. Finally, Principle 7 encapsulates the six data ecofeminist principles by challenging Western epistemologies on science and technology, strongly relating to Data Feminism's Principle 5 on embracing pluralism.

These principles also constitute a call for action-guiding discussions. To this end, Table 1 illustrates how they can be translated into specific actions for the FAccT community and technical audience, as well as guide policy interventions for policymakers and practitioners.

6 Conclusion

Are there ways of developing data and AI technologies from an ecofeminist perspective? Data ecofeminism is a theoretical and analytical framework made up of seven principles that aim to respond to this question by delineating the pathway toward developing data and AI technologies that put *care* at their core, while respecting life, people, and the planet. While the accident at the Three Mile Island nuclear power station in 1979 set the precedent for the first ecofeminist group and conference in the US, the reopening announcement of this nuclear station in 2024 to power GenAI technologies invites a reconsideration of how ecofeminist epistemologies confront these technologies and their industry—similarly to how feminism confronted technologies decades ago [139]. With the growing resource-intensive technologies like GenAI, which are putting into question how AI could tackle climate change, the *Data Ecofeminism* principles offer seven dimensions of theoretical and practical guidance to critically advocate for sustainable technologies. These principles, rooted in the world-leading work of Data Feminism [35], integrate an ecofeminist perspective toward AI and data science by bridging the gap between social and environmental justice. Rather than merely accounting for carbon emissions and water usage of AI, Data Ecofeminism calls for remaining critically and politically aware of the structural and historical mechanisms that sustain this technology today, offering a guide to develop radical alternatives that keep the Earth's temperature rise to 1.5°C, in line with the Paris Agreement [132].

Ecofeminist movements and critical feminist STS scholars have commonly pointed out that Western science and technology, rooted in the Enlightenment and the logic of reason, has been imposed to dominate the body and the territory, women, and nature. In doing so, it has also disrupted and commodified nature for market profit [88]. As an example, technologies such as nuclear power and weapons have been at the forefront of ecofeminist critiques, illustrating how these technologies function as tools of 'death' rather than 'life' due to the detrimental consequences nuclear energy can have on life on our planet. Given the current trend of AI development, with the big tech industry investing in nuclear reactors to power GenAI systems alongside the large number of resources needed to train these models, this paper proposes bringing ecofeminism into the critical AI scholarship, not only to illustrate how feminist values could be useful in building technology but also to guide us towards a just transition alternative that 'does not reproduce an exploitative relationship with nature and ourselves' [139, p. 59].

This paper also offers a provocation towards the GenAI innovation race, questioning whether these technologies are going to foster a safer planet for our future generations. Data ecofeminism confronts GenAI technologies, which are presented as the latest technocentric experiment clearly contributing to the social-ecological crisis [15, 16, 27]. However, this ecofeminist approach is not against technology, because 'ecofeminism believes that critical technology use involves careful, context-specific implementation with a focus on the needs of particular local or Indigenous social groups and of the ecological situation' [85]. These principles serve as action-guiding frameworks, delineating multiple pathways for developing AI technologies that support a just transition towards environmental sustainability. The seven principles of data ecofeminism involve acknowledging the power relationships within climate change, recognising that the Global North is contributing more to it, considering the environmental costs of making AI by examining its materiality and supply chains, holding AI environmental costs accountable by publicly publishing environmental metrics, integrating a degrowth perspective, reclaiming digital sovereignty, protecting the digital and non-digital commons through mutual aid, and embracing Native epistemologies that have been dismissed in Western science and technology, and ultimately, aiming to build a world of many worlds where everyone fits.

Finally, it is important to acknowledge my positionality as a white woman academic researcher from a well-established institution in Europe, which inevitably shapes the formulation of these ecofeminist principles. This positionality represents a limitation of the proposed ecofeminist framework, acknowledging the critical voices against white ecofeminism. Nevertheless, I offer this work not as a definitive statement but as an invitation to broaden critical discourse regarding the GenAI innovation race through ecofeminist perspectives. I recognise that a more comprehensive framework would benefit from diverse voices, particularly those from communities most affected by environmental degradation and socio-technical inequality. My hope is that this initial contribution will stimulate further dialogue, critique, and collaborative refinement within the FAccT community and beyond.

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