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The Compatibility Between SDGs and the EU Regulatory Framework of AI

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In Europe, there is increasing recognition of the ethical challenges associated with designing and developing Artificial Intelligence (AI) and Machine Learning (ML) systems, especially concerning their potential impact on fundamental rights. As a result, ethics frameworks and guidelines have been issued by stakeholders in both the private and public sectors. At the same time, fostering innovation in the field is also crucial. The implementation of the European Union (EU) sustainability goals is one area where AI/ML is expected to make a significant contribution, but there are important considerations to address. The expanding reliance on data storage and the subsequent increase in electricity consumption due to advancements in AI/ML have significant implications for greenhouse gas emissions. This paper examines the regulatory landscape for environmental sustainability using an institutional analysis contrasting the ethical frameworks and current normative standards applicable within the EU. The purpose is to identify a realistic and practical interpretation that prioritizes the development and implementation of AI/ML in a way that facilitates a smooth transition towards the sustainable usage of digital and automated technologies.

Keywords: AI/ML, ethics, EU, Sustainability Goals, environment, legal, institutional analysis

Introduction

As AI/ML technologies progress through the specification phases of their innovation cycles, there is an increasing need for clarity regarding rules, standards, and processes (Solarte-Vasquez, 2013 p. 4). At the same time, the market landscape reveals that leading companies tend to strategically seek advantages to navigate the complexities of evolving socio-technical demands and the broader regulatory environment, and often achieve to secure those advantages with legislative support (Solarte-Vasquez, 2013 p. 9).

With AI/ML undergoing remarkable breakthroughs, under unprecedented scrutiny and social awareness, the ethics of technology have become central in the current regulatory and scholarly discourse, owing to their profound societal impact and on the complex and scarcely studied data-driven ecosystems taking shape. The realization that ethical considerations are crucial in digital and AI transformations, has motivated private industries and stakeholders in the public sector to be more proactive than ever before, addressing concerns early and issuing a variety of guidelines (Silva, 2021 p. 2), rules, and frameworks (AI Regulation White Paper, 2023 p 16*)* to keep AI/ML in check. In Europe, significant advancements have been achieved to guarantee that the implementation of principled policies and human rights protection mechanisms it has instituted remains unaffected, especially when technologies may be fully or partly in charge of decision-making processes. One of the byproducts of those regulatory initiatives is that society accelerates its efforts to grapple with the intricate issues arising from the expanding complexity and autonomy of algorithms (Floridi & Taddeo, 2016 p. 2).

The EU Commission tasked the High-Level Expert Group on AI (AI HLGE) with preparing its 'Ethical Guidelines for Trustworthy AI' (European Commission, 2019), which are grounded on lawfulness, ethics and robustness principles (Larsson, 2020, p. 444; Göksal et al., in press). The document stresses the importance of aligning AI systems with EU values, while considering various administrative and organizational factors that encompass social and economic perspectives. In addition, this regulatory strategy specifically aims to ensure that AI technologies support both societal well-being and environmental integrity (European Commission, 2019).

AI/ML is expected to support the achievement of the United Nations (UN) Sustainable Development Goals (SDGs). In 2020, a study by Vinuesa & Co suggested that AI could act as an enabler on 134 of the 193 UN targets (79%), supporting climate change impact modelling and low-carbon energy systems, with high integration of renewable energy and energy efficiency (Vinuesa et al., 2020 p. 2). These goals, formulated in 2015 and integrated in EU from 2021 under the UN 2030 Agenda for Sustainable Development, embody a global consensus on promoting positive social change and preserving the natural environment (Cowls et al., 2021 p. 2). As internationally and supranationally convened objectives, the SDGs have become an uncontroversial benchmark for defining and evaluating the societal impact of AI (Cowls et al., 2021 p. 4).

However, it is essential to avoid an overly optimistic outlook regarding AI's for achieving the SDGs (Karnama et al, 2019, p. 3). For instance, there is evidence of potential biases in reporting AI impact what leads to the need for control, monitoring and accountability protocols regarding environmental outcomes (Vinuesa et al., 2020, p. 6, Sætra, 2021, p. 23). Also, while AI may have a positive role to play in biodiversity monitoring and conservation, an excess of AI-related information on ecosystems could create the wrong incentives. It could, for instance, lead to resource overexploitation and potentially cause detrimental effects on 59 of the 193 UN targets (35% across all SDGs) (Vinuesa et al., 2020, p. 2). Other substantial risks are tangentially discussed, notably, the exacerbation of social and climate-related problems in the short and long term (Vinuesa et al., 2020, p. 3), and the high energy requirements of producing and maintaining AI applications, especially the non-carbon-neutral, that could hinder climate action efforts (ref on SDG13).

Despite the initiatives like the EU Green Deal (Fetting, 2020) and the AI Act (European Commission, 2021) being implemented alongside the ongoing development and adoption of AI/ML in the region, the deployment and usage of computation-intensive AI systems will exponentially raise energy consumption and generate digital waste (Freitag et al., 2021 p. 3). Moreover, many current guidelines underrepresent the financial strains and/or the broader social and ecological costs associated with these systems (Hagendorff, 2020 p. 101; Bogani et al., 2022 p. 1137), revealing a gap between ethical considerations and the sustainability aspects addressed in regulatory practices.

This study explores the dynamic intersection of AI/ML with sustainability, focusing on the regulatory landscape at international and supranational (EU) levels and due the complexity of those domains, the study will extend beyond mere legal structures, it also considers the broader institutionalization levels that guide and influence these critical domains from the sense-making meaning, theoretical background and legal and policy instruments in place.

It is considered essential to recognize some overlooked questions by broadening the scope of inquiry and scrutinizing these challenges more systematically. A more comprehensive assessment is a precondition for a proper institutional and regulatory treatment of AI/ML and other technologies if especially to mitigate potential adverse effects and maximizing the technology's positive impact on society and the environment.

The next section will cover the methodological and conceptual background, bringing in fundamentals of AI/ML and sustainability, also presenting data regarding the potential negative effect of AI/ML. The following part is dedicated to designing the current landscape of AI/ML regulatory frameworks and their connection with ethics and sustainability. The last part will speak about the pathways for a smooth transition towards integrating AI regulation and the SDGs, providing realistic and practical interpretation. The conclusion aims to gather the main information and spots insights and the existing research gaps.

2. Institutionalization of Key Concepts

The rapid evolution of digital and AI technologies presents a multifaceted challenge that encompasses the inherent complexity of these systems. (Wang, 2019, p. 63), rendering them opaque and difficult for humans to comprehend and trust (Martin, 2019 p. 844). One hurdle lies in the reconciliation of regulatory orientations across fields such as AI technology and environmental sustainability. The paradox is stark: digitalization and automation, while indispensable for modern societal and economic functions, inherently contribute to environmental degradation. The contradiction becomes manifest in the increasing reliance on data, which necessitates expanded storage and escalates energy consumption, thereby exacerbating CO_2 emissions (Belkhir & Elmeligi, 2018 p. 448). This situation presents a formidable obstacle to adhering to environmental legislation, which often seems at odds with the realities of technological advancement.

On the other hand, AI/ML can be understood as a complex social, cultural, and material entities. that impact society (Eynon & Young, 2021 p 166). The institutional framework is intimately related to that because it governs social interactions (DeMattee, 2023 p. 530; Siddiki, 2021 p. 213), through normative discourses from formal and quasi-formal to informal regulatory expressions, such as ethics, doctrine and the practice. Consequently, law and ethics share important characteristics for being both regulations and principled (Cook, 2019 p. 485).

Similarly, formal and informal institutions are different because the first are binding and issued by authoritative entities, whereas the second are not mandatory but rooted in cultural, sectorial, organizational and customary practices (Barbalet, 2022 p. 72). Studying the two kinds is crucial in understanding the broad regulatory context and contemporary governance strategies in certain jurisdictions (Joamets & Solarte-Vasquez, 2004 p. 21). With this in view, to better address the questions at hand calls for an institutional analysis that emerges as a good method to map and make sense of the regulatory systems, looking into various kinds of regulatory expressions, from laws and policies to scholarly models and strategies (Siddiki, 2021 p. 214), as well as their applications, challenges and compatibilities.

The institutional analysis as in Solarte-Vasquez & Joamets (2020), will be limited in scope to sense making and a systematic appraisal of the spread of concepts as embedded or considered in the evolving legal framework. Therefore, it will survey the informal and formal regulatory landscape to investigate the alignment and consistency between the two concepts and their legal determination: 'sustainability' and 'AI/ML,' (considering the current digital and AI transformation) at the supranational level. Given that multilateralism has been claimed to be a key objective of the EU, and the ties between the EU and international institutions have grown in a "*more sustained and consistent*" way (Jørgensen, 2009 p. 188), the analysis will include selected international sources.

The framework to address will comprise laws and regulations, at the policy-making level based on 3 criteria: Institutionalization Level (international or Supranational), format and source (formal or informal, and binding non-binding), and scope of within the regulatory landscape, that is concerning sustainability or AI/ML categories.

In the given context, the determination of rules via formal institutions provide certainty and inform decision making, shaping the relationships among individuals, groups and other entities, and enabling the achievement of "commonly valued outcomes" (Siddiki, 2019, p. 316). They are structured and enforceable. In here, the selected formal institutions mean any type of context specific rules that are issued under public sector allowances and constraints (Crawford & Ostrom, 1995; Searle, 2005), which are guided in their formulation by the rule of law principles, including laws, administrative acts, public policies and other public sector regulations (Siddiki, 2019, p. 317). The understanding of regulatory norms of this kind, as defined by Casev & Scott (2011), involves descriptions of conduct linked to sanctions.

Regulating digital and AI technologies in alignment with environmental sustainability goals is an enormous challenge, demanding a comprehensive understanding of the interactions among technology, legal frameworks, and environmental ethics. Therefore, to establish the foundation for a detailed exploration of the intricate relationship between AI/ML and sustainability is needed. The next subsections will begin by delineating the informal institutional environment.

2.1. Artificial Intelligence

The first mention of AI is credited to John McCarthy, in a 1956 proposal for the Dartmouth Summer Conference as the theoretical conception of machines exhibiting human intelligence (McCarthy, et al., 1955, page 2). Almost 70 years later, there is still no universal definition, but technology keeps permeating all facets of society, often invisibly in the background (Ben-Ari et al., 2016, p. 5).

The Cambridge Dictionary[1] states that several definitions narrowly refer to 'AI' as machines or systems that behave like humans or are capable of actions requiring intelligence. There are various definitions for AI/ML in academic literature. Table 1 below groups various definitions for AI.

Table 1. AI definitions across different institutions

Source	**Definition**
Poole, 1998 p. 1	*"Intelligent agents," which are devices that "perceive their environment and take actions to maximize their chance of success at some goal"*
Duan et al., 2019 p. 63	*"Is commonly referred to as a machine's ability to learn from experience, adapt to new inputs, and perform human-like tasks."*
Cowls et al., 2021 p. 112	*"Machines' ability to learn from experience, adapt to new inputs, and perform human-like tasks."*
Dignum, 2021 p. 2	*"a software system, potentially integrated into hardware, that is created by humans, that exhibits the attributes of autonomy, adaptability and interactivity. This system, when confronted with intricate objectives, demonstrates the ability to make decisions through a process of perceiving, interpreting, and reasoning based on data gathered from the surroundings"*

Source: original compilation.

The analysis of the definitions highlights the multidimensional nature of AI and the diverse perspectives within the field, which makes it difficult to define and understand in legal and regulatory contexts. It is possible to identify striking similarities and the more evident is the acknowledgment of AI as machine-related systems capable of learning from experience, adapting to new inputs, and performing tasks. This foundational characteristic is consistent across definitions, reflecting a shared understanding of AI's core functionalities and capabilities and underscoring its dynamic nature and potential to continuously improve itself. Another constant is the parallel to hu-

[1] Cambridge University Press. (n.d.). *Cambridge Dictionary.* Retrieved March 17, 2024, from https://dictionary.cambridge.org/

man cognitive functions, what may indicate the drive to emulate human-like behaviors and cognitive processes. Finally, definitions acknowledge AI's impact on environments, whether physical or virtual, emphasizing its ability to generate outcomes such as predictions or decisions.

But there are striking common points, the mere comparison of some definitions shows the inconsistencies such as the level of perception and Action, learning and adaptation and finally the attributes of autonomy and interactivity.

In turn, The Cambridge Dictionary conceptualizes ML as "the process of *computers improving their own ability to carry out tasks by analyzing new data, without a human needing to give instructions in the form of a program, or the study of creating and using computer systems that can do this*"[2]. ML is also understood as a subset of AI that demonstrates the ability to learn and improve its assessments through computational methods, without the need to be explicitly programmed, which might be associated with human intelligence (Bini, 2018 p. 2359). These algorithms recognize patterns in massive volumes of data inputs and outputs and effectively "learn" to educate the computer to make autonomous suggestions or decisions (Helm et al., 2020 p. 69). The "learning" is a dynamic process, involving training machines with provided data, allowing modifications when exposed to more data, with the aim of minimizing errors and maximizing prediction accuracy (Jakhar & Kaur, 2020 p. 131).

2.2. Sustainability

First mentioned in the report 'Our Common Future' in 1987, the Brundtland Report, as the "*development that meets the needs of the present without jeopardizing future generations' ability to meet their own needs*" (Brundtland Report, 1987 p. 37).

The Cambridge dictionary[3] shows 2 aspects of sustainability: the "*quality of being able to continue over a period of time*", and "t*he quality of causing little or no damage to the environment and therefore able to continue for a long time*". Both concepts evidence the idea endurance of humankind and, at the same time, to connect the present and the future. Another aspect to highlight is the restrictions imposed by technological and social organizations on the environment's ability to meet present and future needs.

'Sustainability' is related to the concept of long-term viability and growth, stressing the value of balance, resilience, and resource management, referring to the endurance of natural systems and has been extensively used to

[2] idem 1
[3] idem 1

evaluate the level of sustainable development achieved (Zhou et al., 2018 p. 12).

Traditionally, sustainability has been approached through three dimensions—ecological, economic, and social (Toniolo et al., 2023 p. 3) —for over 30 years. The ecological or environmental dimension speaks of the impact of human actions on the world, highlighting the importance of human progress in identifying planetary boundaries and working to prevent dangerously massive environmental change. The economic dimension involves strategies that stimulate long-term economic growth without adversely affecting the social, environmental, and cultural aspects of communities. Finally, the social dimension relates to achieving a sufficient level of social homogeneity, equitable economic distribution, fair public access, and communities that foster social contact and investment in communities while respecting their particularities. (Kates et al., 2001 p. 642).

Nevertheless, the traditional perception has been shifting and being amplified. Figuière and Rocca (2008 pp. 7-9), proposed the anthropic-centered model of sustainability, encompassing five dimensions (5D). This framework directs sustainability goals toward human development (social dimension). The environment is perceived as a constraining factor for human activities (ecological dimension). The economic dimension is viewed as a tool, rather than an end, facilitating the achievement of social objectives within ecological constraints. The political dimension plays a crucial role in outlining development guidelines and must possess the strength to supersede economic actors. It serves as a forum for public discourse, long-term societal orientation, and decision-making. Public policies are deemed the legitimate means to define the public interest and common good, ensuring the coordination of sustainable industrial strategies and alignment with civil society expectations. Finally, the territorial dimension is also recognized, requiring the adaptation of global policies to local specificities for the development of tailored solutions.

The concept has been changing, to comply with social and organizational contexts. Initially it was based on the objective of finding consensus between the ideas of different actors about (un)sustainable development; or on an environmental logic that did not distinguish between the history of nature and that of society (Lounsbury et al, 2021 p. 268). Currently, sustainability is acknowledged as a systemic attribute, implies that individual products, services, technologies, or organizations cannot achieve sustainability independently but can contribute as elements within sustainable systems. It also involves avoiding the systematic degradation of global socio-ecological system resources (Toniolo et al., 2023 p. 2).

So, while the pursuit of sustainability has historically relied on traditional principles, the contemporary landscape demands a reevaluation of our approaches. In this context, emerging technologies, particularly AI, have garnered attention as potential catalysts for large-scale changes needed to achieve sustainable societies. Yet, it is essential to navigate the intricate dynamics and potential challenges linked to the evolving relationship between AI and sustainability initiatives.

The environmental impact of data usage in AI training is profound and multifaceted. Deep learning algorithms, essential for AI models, require massive datasets for training and inference, driving substantial energy consumption and resource utilization in computing and storage infrastructure. So, by one side, data centers provide the necessary infrastructure to handle vast datasets and complex calculations, ensuring AI applications operate reliably with high-speed processing it also consumes huge amounts of energy and water, contributing to carbon emissions and resource depletion. As AI technology continues to expand across industries, sustainable data management practices are essential to mitigate these environmental challenges and ensure a more environmentally conscious approach to AI development and deployment (Ferreira et al., 2019 p. 2).

In general, AI is considered advantageous for driving the large-scale changes needed to achieve sustainable societies (HELG, 2018). Nonetheless, it's crucial to acknowledge that an excessive focus on technological innovation, particularly AI, could obscure the essential societal decisions required to meet sustainability goals. The integration of AI into sustainability efforts demands a holistic approach, recognizing that AI's entire life cycle must not inadvertently contribute to a larger ecological footprint on the planet (van Wynsberghe, 2021 p. 215).

2.3. Environmental Downsides of AI/ML

There is an accepted notion that AI/ML AI applications could not only help fight climate change but also support dealing with other environmental and economic growth issues. This is an oversimplified vision and the motive why it is necessary to shed light on the hidden environmental dilemma surrounding AI.

Generally, AI/ML is seen as an "*abstract, non-tangible technical system*" (OECD, 2022 p. 5) but it is enabled by physical infrastructure and hardware which requirements have skyrocketed over the last decade, ushering in what some refer to as the ´Large-Scale Era´ of computing. Calculating the exact impact of AI on the climate is difficult, as different types of AI require various levels of computing power to train and run. As network depth increases, so does computer complexity, requiring higher computational power and longer training times, together with larger physical spaces to store the data used to train the AI applications. Additionally, the load of datasets used in AI increases complexity and makes it difficult to track their usage. The lack of transparency further complicates understanding the impact of AI models.

AI was presented under two risk categories: danger from major problems brought on by burning issues, such as accelerators and society collapse, and danger from unforeseen repercussions like pandemics and climate change (Bostrom & Cirkovic, 2011 p. 15).While AI applications yield both positive and negative effects, the direct environmental repercussions of AI compute tend to be predominantly negative, particularly in terms of greenhouse gas (GHG) emissions and resource utilization, as compute infrastructure often demands substantial energy and material inputs (Barteková & Börkey, 2022 p. 39).

Furthermore, AI requires massive amounts of computing power, and those computers require electricity and the necessary units run extremely hot, which require cooling, the technology is highly electricity consuming. This, in turn, means large-scale CO2 emissions, about which the industry is extremely coy, while boasting about using offsets and other tactics to pretend to be carbon neutral. Simply training a model is extremely energy-intensive, consuming far more electricity than traditional data center activities. The training of a large language model, such as GPT-3, is expected to use less than 1,300 megawatt hours (MWh) of electricity. This is equivalent to the annual power consumption of 130 US homes. However, this figure is not exact because AI models have been steadily increasing in size for years, and the larger the models, the more it consumes energy.[3] In the last decade, there are reports that data center energy consumption has remained flat at around 1% of global electricity demand (IEA, 2021), despite significant increases in workloads and data traffic, of which AI is expected to account for a small portion. While this may indicate increased hardware efficiency, some researchers point out that AI compute demands have grown faster than hardware performance, raising the question of whether such gains can be sustained.

As underlined by the OpenAI organization, the computer power required to train cutting-edge AI models has doubled every 3.4 months since 2012[1]. This brings the equation to an estimated 300,000-fold increase from 2012 to 2018, far exceeding Moore's Law, that says that the overall processing power for computers will double every two years. The training process of common large AI models. They found that the process can emit close to 283 ton of carbon dioxide equivalent— close to five times the lifetime emissions of the average American car, including the manufacture of the car itself or more than 626 years of life of a regular human being.[2] In 2020, the carbon footprint of Information Computational Technology (ICT), including AI/ML, was estimated to range between 1.8% to 2.8% of total emissions, encompassing GHG emissions from various stages such as raw material extraction, manufacture, use, and end-of-life disposal (Freitag et al., 2021).

In the next section, the focus shifts towards the exploration of the regulatory landscape. It will thus refer to the formal institutions at the international and EU regulatory levels as indicated above. The aim is to unravel the intricate relationship between legal structures, environmental ethics, and the evolving landscape of AI and sustainability, highlighting the intersections in this dynamic relationship.

3. Formal Institutions and Legal Frameworks: Shaping the AI and Sustainability Discourse

The key official initiatives with impact in the regulatory efforts providing guidance and establishing standards for the responsible integration of AI/M will be mapped. Additionally, the subsection explores the intersection of AI and sustainability in the context of international and EU regulations.

3.1. The Regulatory Treatment of AI/ML and Sustainability at the International level:

International Law, despite its decentralized and voluntary nature reliant on state consent, sets formal institutions, guides discourses, and fosters legal development. It contributes to consistency and fairness in decision-making processes. Although a comprehensive international treaty specifically addressing AI/ML is absent, initiatives like the OECD AI Principles and the Council of Europe's Convention on AI/ML lay essential groundwork for global regulation.

The OECD AI Principles, signed in May 2019, establish standards for governments grappling with the ethical and practical implications of AI. It is the first benchmarking document to be approved by many nations, including non-OECD members like Brazil and Romania, outlining principles of inclusive and sustainable growth and well-being, human values. It also tackles issues such as fairness, transparency and explainability, robustness, safety, and accountability (Carter, 2020 p. 37). It also highlights the importance of promoting responsible stewardship of trustworthy AI systems in pursuit of inclusive growth, sustainable development, and well-being. This is articulated in Section 1 of this framework, particularly under Article 1.1, which calls on stakeholders to proactively engage in AI development to achieve beneficial outcomes for people and the planet. It also emphasizes the role of AI in augmenting human capabilities and protecting natural environments, aligning with the SDGs set out in the United Nations' 2030 Agenda[4].

Moreover, with the aim to be binding and enforceable, the Council of Europe (CoE) is spearheading the development of the Framework Convention on Artificial Intelligence, Human Rights, Democracy, and the Rule of Law (AI Convention)[5]. This convention pursues to provide a concrete framework to regulate AI systems, upholding human rights on a global scale. One of the key characteristics is the ambition of having such reach with its human rights-based proposal, incorporating assessments, an actor-neutral lifecycle approach, and the creation of enforceable rights under the jurisdiction of the European Court of Human Rights (Committee of Ministers, 2024, p. 5).

Specifically, in the AI Convention, the Preamble and Chapter I lay out the foundational principles and objectives governing the design, development, and application of AI systems. Because it is rooted in the values of human rights, democracy, and the rule of law, the Convention aims to ensure that AI technologies promote human prosperity, well-being and progress. The preservation of the environment is explicitly protected in article 11 of Chapter III, indicating it as a duty or obligation of the Parties. In addition, article 16 emphasizes the importance of considering sustainability and environmental factors alongside the assessment of risks and impacts associated with AI systems. It also emphasizes the severity, probability, duration, and reversibility of risks and impacts on the environment should be considered in the risk management framework.

Those indications reflect a more holistic approach to AI governance, encouraging responsible innovation that upholds human rights, promotes democratic principles and contributes to sustainable development goals. Also, it became evident the potential to strengthen human rights protection. However, there are concerns about compromising its impact due to political considerations, highlighting the need for careful deliberation and stakeholder consultation in its development (van Kolfschooten & Shachar, 2023, p. 138).

A comparison between the outlined in the OECD AI Principles and the AI Convention, could serve to highlight the core values and priorities embedded within each framework, and show their respective approaches towards

[4] United Nations. (2015). Transforming our world: The 2030 agenda for sustainable development. United Nations. https://sustainabledevelopment.un.org/post2015/transformingourworld

[5] van Kolfschooten, F., & Shachar, A. (2023). The AI Convention: A Comprehensive Framework for Governance. Council of Europe. https://search.coe.int/cm/Pages/result_details.aspx?ObjectID=0900001680af5d67

ensuring responsible and ethical AI/ML lifecycle. **Table 2** summarizes the similarities and differences between the two.

Table 2. Comparison of OECD and AI Convention Principles

Principles	**OECD AI Principles**[6]	**AI Convention**[7]
Human Rights	Respecting human rights, inclusive growth, sustainable development, and well-being	Equality and Anti-discrimination
Transparency	Ensuring transparency and accountability	Transparency and Oversight
Fairness	Promoting fairness and non-discrimination	Equality and Anti-discrimination
Accountability	Establishing accountability mechanisms	Accountability, Responsibility and Legal Liability
Privacy and Security	Safeguarding privacy and security	Privacy and Personal Data Protection
Collaboration	Encouraging international cooperation	Not explicitly stated*
Ethical Considerations	Addressing ethical considerations in AI	Not explicitly stated*

Source: Original compilation

From the comparison above, it is possible to highlight their shared commitment to promoting responsible and ethical AI development while prioritizing human rights, inclusive growth, and SDGs. Also, both frameworks address sustainability through their focus on inclusive and sustainable growth. This is underlined by section 1 of The OECD AI and article 16 of the AI Convention in article 16. Particularly, the AI Convention's recognition of environmental preservation as a duty of the Parties underscores the importance of considering environmental impacts within AI governance.

[6] OECD. (2019). Recommendation of the Council on Artificial Intelligence. OECD/LEGAL/0449. Retrieved from https://oecd.ai/en/ai-principles

[7] Council of Europe. (2021). Terms of Reference of the Committee on Artificial Intelligence for 2021. Retrieved from https://rm.coe.int/terms-of-reference-of-the-committee-on-artificial-intelligence-for-202/1680a74d2f

The integration of AI governance and sustainability within international legal frameworks presents both opportunities and challenges. These initiatives set important standards for responsible AI, emphasizing principles of inclusivity, sustainability, and human rights. However, key challenges remain. Enforceability and implementation pose significant hurdles, given the voluntary nature and the absence of a comprehensive international treaty in AI/ML, that might be mitigated by the AI Convention.

But while sustainability is acknowledged in both frameworks, more specific measures are needed to integrate environmental considerations into AI governance effectively. That means that the practical implications require translation into actionable policies to bridge the implementation gap and achieve tangible outcomes in reducing inequalities and enhancing environmental protection.

The idea of a worldwide struggle with problems related to energy resource exhaustion, environmental degradation, and climate change has been adopted in several international policies. For instance, both The Paris Agreement (Wang & Siau, 2019) and the UN SDGs address these pressing issues. The Paris Agreement, a legally binding treaty, specifically targets climate change mitigation and adaptation through nationally determined contributions (NDCs) submitted by signatory parties. In contrast, the UN SDGs, while not legally binding, serve as a foundational policy framework for promoting sustainable development across various dimensions, including environmental protection. Additionally, both frameworks recognize the interconnectedness of environmental, social, and economic issues and emphasize the need for coordinated action at the international level.

Table 3 presents a comparison between the Paris Agreement and the UN SDGs frameworks under selected analytical parameters. that offer a more detailed overview of how these frameworks tackle sustainability challenges.

In this context, international agreements on environmental protection are considered crucial for fostering a green environment and ensuring equitable global benefits. Specifically, the Paris Agreement, through concerted efforts and commitments from participating nations, focuses on climate change mitigation (Doğan et al., 2022, p. 124), while the UN SDGs address a broader spectrum of sustainability goals. Serving as a comprehensive blueprint, the UN SDGs encompass various aspects of sustainability, including environmental protection, social equity, and economic development, providing a holistic roadmap.

Together, these international agreements serve as guiding beacons, steering global efforts towards a more sustainable and resilient future. Moreover, they underscore the shared responsibility of nations to safeguard the planet for present and future generations, emphasizing the imperative of collective action in addressing pressing environmental challenges.

Table 3. Comparative table among International Sustainability Regulations

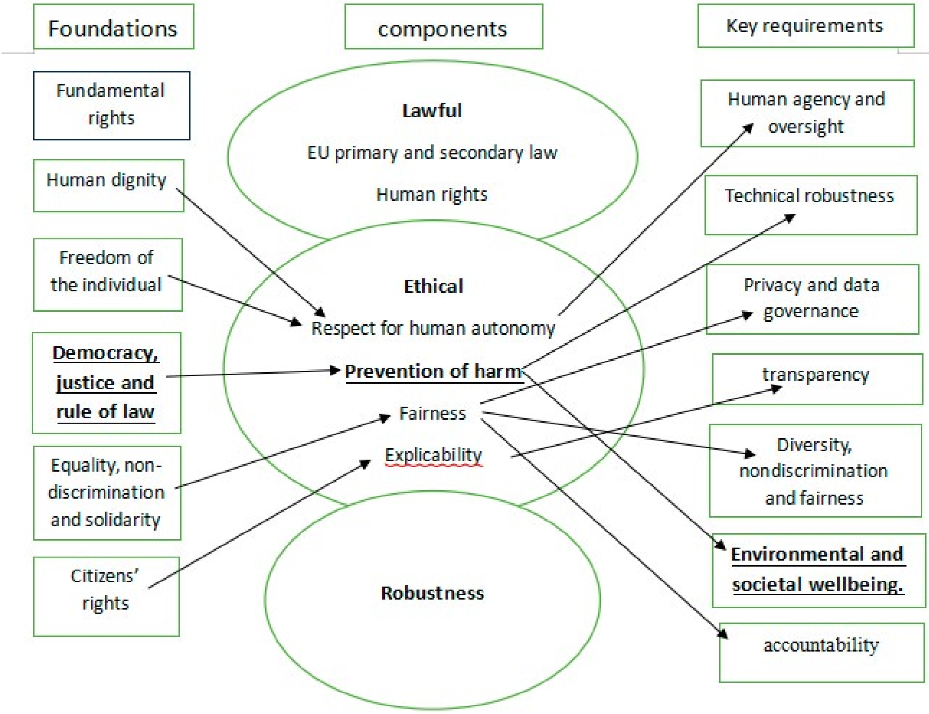
Aspect	Paris Agreement	UN SDGs
Objective	Limit global warming to well below 2 degrees Celsius, pursue efforts to limit it to 1.5 degrees Celsius	A universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity
Scope	Focuses on mitigation, adaptation, and finance	Addresses a wide range of issues including poverty, hunger, health, education, gender equality, clean water, and climate action
Legal Status	Legally binding agreement	Non-binding framework
Key Components	Nationally Determined Contributions (NDCs), Global Stocktake, Long-term goal of decarbonization	17 Goals with 169 targets and 232 indicators
Addressing SDGs	Indirectly through mitigation and adaptation efforts	Directly addresses several SDGs related to climate action, poverty, health, education, etc.

Source: Original compilation

3.2. The Regulatory Treatment of AI/ML and Sustainability at the EU level:

The EU has been instrumental in shaping guidelines for the development of trustworthy AI, emphasizing key principles crucial for ethical AI systems. According to the EU, trustworthy AI is grounded on three foundational pillars: lawfulness, ethics, and robustness, as defined by the EU Ethical Guidelines for Trustworthy AI (HELG, 2019). These guidelines set the groundwork for seven essential requirements outlined by the European Commission's High-Level Expert Group on AI (HLEG), covering aspects such as human agency and oversight, technical robustness and safety, privacy and data governance, transparency, diversity, non-discrimination and fairness, societal and environmental well-being, and accountability. In addition, each of them spans various components and dimensions, underscoring the importance of a holistic and systemic analysis throughout the AI life cycle. This intricate relationship is outlined in **figure 1**.

Figure 1. The relationship between the foundations of trustworthy AI and Sustainability



Source: Created by the author based on HELG Guidelines for Trustworthy AI

In the EU context, the AI HLEG definition worked as the starting point for shaping the operational definition for AI, encompassing elements like perception, understanding, interpretation, interaction, decision-making, adaptation, and goal attainment (Samoili et al., 2020 p. 13). The group defined AI as a Human designed system that exhibits intelligent behavior, analyzing their environment, interpreting data, reasoning, and making decisions, all with some degree of autonomy. At that point, ML was already under the umbrella of AI (HLEG, 2019).

In general, the HLEG Ethical Guidelines (2019) had a substantial impact on EU policy. The legal proposal drew upon the key trustworthy AI requirements, forming the foundation for the legal obligations imposed on any 'high-risk' AI system in the EU. They also worked as a reference, stressing the significance and promise of actionable principles in AI impact on policy (Stix, 2021 p. 3).

On December 8, 2023, after a trilogue involving the EU Commission, Council, and Parliament, a provisional political consensus was achieved by the AI Act, the world's first comprehensive legislation on AI. However, this consensus, the final text is still under revision of the remains pending finalization, with the expectation that both the Parliament and Council will formally adopt the text, transforming it into EU law, anticipated to occur in early 2024. Also, despite prolonged negotiations, last-minute discussions arose concerning the regulation of foundational models and potential concerns about stifling innovation. Notably, the adopted concept of AI is the globally recognized standard developed by the OECD *"An AI system is a machine-based system that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments. Different AI systems vary in their levels of autonomy and adaptiveness after deployment" (OECD, 2024 p. 4).* There are some potential takeaways from this: first, it calls for further support of a global consensus around the AI systems in question and second is broad enough to became easily outdated.

Another marked point is that while the AI Act proposes a risk-based approach, referring to a regulatory strategy that assesses and manages the potential risks associated with AI systems, mitigating potential harms and ensuring compliance with fundamental rights. It also recalls the HLEG Guidelines (2019) raising this guideline to principles, contributing to the design of a coherent, trustworthy and human-centric AI/ML, what is in line with the Human Rights Charter and with EU values.

Table 4 makes an overview of the principles enshrined in the AI Act, that are meant to become the basis of the future development and deployment of AI/ML in the EU.

In line with the broader global agenda for sustainability and its importance, the AI Act acknowledges the necessity to integrate environmental considerations into the development and deployment of AI systems. Recognizing the potential environmental impact of AI technologies, particularly concerning energy consumption and resource utilization, the Act emphasizes the importance of fostering sustainable practices across the AI ecosystem. It calls for the promotion of energy-efficient programming and design techniques, aiming to minimize the carbon footprint associated with AI systems. Moreover, the Act encourages the adoption of AI solutions that contribute to environmental sustainability, such as those facilitating resource efficiency and supporting the transition to clean energy sources.

Table 4. Summary of the AI Act principles

Principle	**Description**
Human Agency and Oversight	It should serve people, respect human dignity and personal autonomy, and be appropriately controlled and overseen by humans.
Technical Robustness and Safety	It should be developed and used in a way that allows robustness in case of problems, resilience against attempts to alter performance unlawfully, and minimizes unintended harm.
Privacy and Data Governance	The systems should comply with existing privacy and data protection rules, ensuring data processing meets high standards of quality and integrity.
Transparency	They should allow appropriate traceability and explainability, making humans aware when they interact with AI systems and informing deployers and affected persons about capabilities and limitations.
Diversity, Non-Discrimination, and Fairness	Their systems should include diverse actors, promote equal access, gender equality, and cultural diversity, while avoiding discriminatory impacts and unfair biases prohibited by Union or national law.
Societal and Environmental Well-being	AI/ML systems should be developed and used in a sustainable and environmentally friendly manner, benefiting all human beings, and monitoring and assessing long-term impacts on individuals, society, and democracy.
Accountability	It should be subject to mechanisms that ensure responsibility and accountability for their development and use, including addressing potential impacts on individuals, society, and the environment, and providing remedies in case of adverse effects.

Source: Original compilation

However, those sustainability related provisions are sparse in the text; **Table 5** provides a summary of them in the last version of the AI Act.

To point out the importance of sustainability in the AI Act, Article 81 emphasizes the necessity of integrating it into the development and deployment of AI systems within the EU. It underscores the importance of promoting ethical and trustworthy AI across non-high-risk systems by encouraging providers to establish codes of conduct and related governance mechanisms aligned with mandatory requirements applicable to high-risk AI systems. To achieve the integration of environmental sustainability in AI system development, there should be clear objectives, with processes and indicators in place to measure their impact on environmental sustainability.

Table 5. summary of the key provisions related to sustainability within the AI Act

Provision	Description
Environmental Well-being	AI systems should be developed and used in a sustainable and environmentally friendly manner, benefiting all human beings, and monitoring and assessing long-term impacts on individuals, society, and democracy.
Ethical Principles	The AI Act refers to the 2019 Ethics Guidelines for Trustworthy AI, which include principles related to societal and environmental well-being, such as human agency and oversight, technical robustness and safety, diversity, non-discrimination and fairness, and accountability. These principles contribute to ensuring that AI is developed and used ethically and responsibly.
Codes of Conduct	Providers of non-high-risk AI systems are encouraged to create codes of conduct fostering the voluntary application of ethical principles, including those related to environmental sustainability. Codes of conduct should be based on clear objectives and key performance indicators to measure their effectiveness.

Source: original compilation.

There are also some key aspects that make the AI Act a landmark achievement: the risk-based approach, to ensure compliance with fundamental rights, and the acknowledgment of the importance of integrating environmental sustainability. This last aspect shows a commitment to environmental stewardship, despite the limited scope.

This also follows the long-term commitment of the EU to the environment, that goes back to the European Council held in Paris in 1972, where the EU consolidated a complex institutional framework to guide environmental policy. This commitment was further solidified by subsequent legal frameworks, such as the Single European Act of 1987, which introduced a dedicated 'Environment Title' aimed at preserving environmental quality, safeguarding human health, and ensuring sustainable resource use. Successive treaty revisions reinforced the EU's dedication to environmental protection and elevated it as an official policy area, until The Treaty of Lisbon, on 2009, that explicitly addressed climate change and sustainable development in EU policy, empowering the EU to engage in international agreements. These advancements culminated in key initiatives like the European Green Deal and the EU Climate Law. The table below summarizes the main aspects of each regulation.

Table 6 presents the main aspects of the 3 main climate-related regulations in the EU in a nutshell, pointing out similarities and differences.

Table 6. Comparative table among EU Environmental Regulations

Aspect	**EU Green Deal**[8]	**EU SDGs**[9]	**EU Climate Law**[10]
Objective	Achieve climate neutrality by 2050, transform Europe into the world's first climate-neutral continent	Ensure sustainable development in the EU by 2030, addressing economic, social, and environmental aspects	The law enshrines the goal of achieving climate neutrality by 2050 and sets a target to reduce net GHG gas emissions by at least 55% by 2030.
Scope	Focuses on climate action, biodiversity, circular economy, sustainable agriculture, and sustainable mobility	Addresses a wide range of issues including poverty, inequality, climate change, environmental degradation, and sustainable development	Covers all sectors of the economy and society, aiming to ensure that all EU policies contribute to the goal of climate neutrality
Legal Status	Policy framework with legislative and non-legislative initiatives	Policy framework and set of objectives, not legally binding	Legally binding, published in the Official Journal on July 9, 2021, and entered into force on July 29, 2021.
Key Components	European Climate Law, Farm to Fork Strategy, Biodiversity Strategy, Circular Economy Action Plan, Sustainable Mobility Strategy	17 Goals with 169 targets and 232 indicators	- Establishes a legally binding target of net zero GHG gas emissions by 2050. - Sets a more ambitious EU 2030 target of reducing net GHG gas emissions by at least 55% compared to 1990 levels. - Includes measures for tracking progress and adjusting actions accordingly. - Introduces a process for setting a 2040 climate target. - Commits to negative emissions after 2050.
Aspect	**EU Green Deal**	**EU SDGs**	**EU Climate Law**

8 The European Commission. (2019). Delivering the European Green Deal. Retrieved from https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal_en

9 European Commission. (2020). Delivering on UN's Sustainable Development Goals [PDF]. Retrieved from https://commission.europa.eu/document/download/1ae1e765-0a3f-4092-b87e-86ecbd1ec0c7_en?filename=delivering_on_uns_sustainable_development_goals_staff_working_document_en

10 The European Union. (2021). Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the European High-Performance Computing Joint Undertaking (EuroHPC JU) and repealing Regulation (EU) 2018/1488. *Official Journal of the European Union*, L 244/1. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R1119.

Addressing SDGs	Indirectly contributes to various SDGs related to climate action, biodiversity, sustainable consumption, and sustainable development	Directly aligned with EU's efforts to achieve the 17 SDGs	Assessment of progress conducted in 2023, highlighting the need for further action to meet climate neutrality objectives and improve adaptation efforts. Recommendations issued to Member States under the European Climate Law based on assessment findings.
Stakeholder Input	Extensive stakeholder consultation and analysis conducted during the preparation of the strategic vision for a climate-neutral EU	Public debate and feedback collected before finalization and adoption of the European Climate Law	Extensive stakeholder consultation and analysis conducted during the strategic vision for a climate-neutral EU. Public debate and feedback collected before finalization and adoption of the European Climate Law

Source: Original compilation

In response to the 2030 Agenda for Sustainable Development adopted by the UN in 2015, the Commission published a communication in 2016 entitled 'Next steps for a sustainable European future – European action for sustainability', outlining how to integrate the SDGs into EU policy priorities. In January 2019, the Commission presented a reflection paper on the SDGs entitled 'Towards a Sustainable Europe by 2030', which puts forward three frameworks for advancing the SDGs.

In December 2019, the Commission unveiled the European Green Deal, a comprehensive strategy aimed at making Europe the first climate-neutral continent that is part of Commission's strategy to implement the United Nation's 2030 Agenda and the sustainable development goals. This idea integrated various EU policy domains, gaining traction, evolving into a horizontal strategy, permeating the whole policy making process, since 2001, when the EU introduced its first sustainable development strategy (SDS)[11]. This commitment is evident in the advocacy for and implementation of ambitious environmental and energy policies, manifested both on a global scale through commitments to the SDGs and domestically through initiatives like

[11] European Commission. (2001). *A sustainable Europe for a better world: A European Union strategy for sustainable development* (Commission proposal to the Gothenburg European Council) [COM(2001) 264 final]. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52001DC0264
European Commission. (2005). *Review of the Sustainable Development Strategy: A platform for action* [COM(2005) 658 final]. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52005DC0658

the EU Green Deal. Specifically, the EU aims to achieve net-zero GHG emissions by 2050 and is actively preparing for climate change adaptation, mitigation, and the scaling up of solutions.

Another positive aspect of this regulation is its acknowledgment of the importance of integrating environmental sustainability, even though this concern remains limited in scope and sparse in the text.

4. Pathways for Integrating AI Regulation and the SDGs

Sustainability and technology are deeply interconnected since the decisions made in developing and adopting technologies carry significant environmental implications. As technology advances rapidly, it both offers solutions to environmental problems and introduces new challenges, exemplified by issues like digital waste. (Kibert, 2010 p. 34). This also results in a profound sense of responsibility towards addressing these impacts, which is also closely related to legal considerations.

As a relational concept, responsibility links subjects to objects, often involving authority and normative foundations. Diverse types of responsibility exist, such as moral, legal, and role responsibilities, each with distinct characteristics depending on the context. In the AI/ML field, there is a complex interplay of individual, collective, and institutional responsibilities, with some well-established and others emerging. In this sense, addressing responsibility prompts questions about allocation and consequences, emphasizing the practical nature of the debate and there are political efforts to integrate existing regulatory mechanisms, adapting human rights approaches to AI and proposing specific legislation like the EU's AI Act (Stahl, 2023 p. 3).

The intricate and new relationship between the environment and AI/ML creates uncertainty for policymakers and necessitates the partial establishment of novel regulatory frameworks to address potential short- and long-term risks for this emerging technology (Taeihagh et al., 2021 p. 1). This implies that, from the public sector standpoint, AI and climate policies are deeply important, in a way that considers all aspects of its impact on climate. That includes considering its applications, but also its emissions and other production costs, such as those associated with water use.

4.1. Addressing Regulatory Gaps:

The regulatory landscape surrounding AI is still evolving, and existing regulations focus on high-profile issues such as bias and lack of transparency but fail to address broader environmental impacts like digital waste and resource utilization.

Because the emphasis is on addressing risks, their likelihood and potential severity, those that do not address genuine risks or fail to effectively target the causes of risks result in increased costs and burdens with no real benefits. Such regulations undermine public trust and endanger the societal aspects that are integral to good policy and rulemaking (OECD, 2021, p. 3). Policymakers must be more proactive and select appropriate regulatory instruments anticipating and stirring the trajectory of technological and societal change, ensuring AI's long-term viability. They must also navigate the complexities of regulating AI while considering the public's trust in tech companies and the broader implications for national competitiveness and economic prosperity (Smuha, 2021 p. 61; Salo-Lahti et al., 2024 p. 245).

The EU's current regulatory approach, balancing voluntary governance with some binding legislation, appears to align well with citizens' preferences (Smuha, 2021 p. 64). Nevertheless, there's a growing call for more robust regulation to ensure environmental sustainability. Trust in tech companies influences citizens' acceptance of regulatory measures, with greater trust correlating with more support for market-based regulations (König et al., 2022 p. 3). However, there's a delicate balance as stricter regulations could hinder innovation and reduce AI's potential societal benefits. Moreover, citizens' concerns about future generations' well-being emerge as the strongest predictor of regulatory support (König et al.,2022 p. 23). This indicates a growing recognition of the sustainability dimension in AI governance and highlights the public's expectation for policymakers to take decisive action to shape the technology's future trajectory. In the context of advancing technology and artificial intelligence (AI), integrating sustainability principles into institutional frameworks becomes imperative.

Addressing the environmental impacts of advancing technology, especially in AI/ML, is urgent due to the rapid proliferation of AI applications what raises concerns about digital waste and resource utilization, that can lead to broader societal implications. In this field, one pressing issue to highlight is the sustainability of data farms, batteries, servers, and the management of digital waste. Moreover, disposing of electronic waste from obsolete AI hardware exacerbates environmental challenges, posing risks to ecosystems and human health. In this sense, sustainability law starts to emerge in the field with these precise concerns in mind, to start to help navigating those contradictions.

To effectively tackle these challenges and achieve a technologically advanced future that maximizes benefits while minimizing dysfunctionality, concerted academic and political activism is essential. This involves integrating environmental sustainability into the design, development, and regulation of AI technologies. Comprehensive frameworks must account for environmental impacts, societal repercussions, and ethical considerations. Prioritizing interdisciplinary collaboration and fostering dialogue among policymakers, researchers, industry stakeholders, and the public is crucial to ensuring holistic solutions that safeguard both the environment and human well-being.

Policy efforts must ensure that AI contributes to meeting global sustainability targets (OECD, 2021, p. 3). This requires addressing measurement gaps related to sustainable AI, including establishing measurement standards and expanding data collection on environmental impacts at national and firm levels. Understanding the broader environmental impacts of AI beyond operational energy use is crucial for developing effective regulatory frameworks.

4.2. Alignment of AI Regulation with Sustainability:

Research indicates that citizens generally advocate for moderate to strong regulation of AI to address key societal challenges related to personal autonomy and environmental sustainability (König et al., 2022 p. 17). König et al. (2022) found significant support for regulation in both transparency and energy efficiency domains, with German citizens urging policymakers to govern these aspects. Interestingly, although consumers may not prioritize transparency and energy efficiency in their personal choices, they still recognize their importance. However, while there is considerable backing for soft regulation methods like information dissemination and positive incentives, support for hard regulations such as bans or legal standards is comparatively lower.

A conceptual alignment between AI regulation and sustainability principles must be grounded in a detailed understanding of the interplay between technological innovation and legal frameworks, integrating environmental principles. Coherence and consistency in defining terms are crucial for legal certainty and predictability. In the legal field, definitions serve to prevent ambiguity in interpretation and justify the application of law (Macagno & Walton, 2010, p. 41).

The EU AI Act is a landmark, representing the first comprehensive legislation enacted by a major regulatory body without internationally binding legal frameworks for AI/ML regulation. Aligned with other significant EU digital legislations such as the GDPR, the Digital Services Act, the Digital Markets Act, the Data Act, and the Cyber Resilience Act, the EU AI Act sets a precedent for comprehensive regulation in the field (Göksal et al., in press).

Several key aspects of the EU's AI definition are noteworthy. Firstly, the definition aims to be 'technology-neutral' and 'future-proof,' ensuring adaptability to new developments and enabling regulation to address emerging risks effectively (European Commission, 2023, p. 4). This approach aligns with the OECD definition, indicating a strategic effort to maintain semantic consistency with international partners. Furthermore, the EU's commitment to clarity and consistency in legal application enhances its legitimacy and fosters public trust. This emphasis on coherence in law promotes fairness, transparency, and accountability (de Waal, 2021, p. 765).

The EU's legislative goals underscore the importance of establishing a legal framework that ensures logical consistency and fosters cohesion and rationality. This holistic approach contributes to the development of a robust regulatory environment that addresses the complex challenges posed by AI technologies while maintaining societal trust and confidence in the regulatory process.

However, coherence does not inherently guarantee the moral or ethical soundness of the laws it encompasses. The elusive nature of coherence complicates attempts to define and achieve it comprehensively, potentially compromising other essential aspects of a legal system, such as flexibility, innovation, and adaptability. Rigid adherence to a singular notion of coherence risks stifling creativity and hindering the evolution of laws to address emerging challenges. Achieving full coherence is an ambitious and potentially unattainable goal, given the complexity of legal systems and the diverse contexts in which they operate.

While coherence in law is a laudable objective, its realization requires careful consideration of its limitations. The European Commission's commitment to "full coherence" reflects a recognition of the importance of consistency and rationality in legal frameworks. However, achieving coherence must be balanced with the need for flexibility to allow for innovation and responsiveness to changing societal needs and values. As legal systems continue to evolve, this quest remains an ongoing endeavor, characterized by continued debate and reflection (de Waal, 2021, p. 767).

Current regulations primarily focus on tangible consequences like unfair decisions or discrimination, which have garnered public attention and media coverage. Even relatively benign consumer applications of AI/ML systems can have dispersed negative effects on other domains, such as the environment, in addition to more significant potential downsides.

Moreover, the landscape of principles remains fragmented (Jobin, 2019 p. 395), and translating them into practice is still a challenge (Mittelstadt, 2019 p. 506). Integrating ethics into governmental policymaking concerning AI has been difficult. While many AI Ethics Principles have been developed by industry actors or researchers for self-governance purposes, a substantial subset is directed towards governmental actors. These include the 2019 OECD Principles on AI and the Guidelines for Trustworthy AI. Despite these efforts, the overall success of AI Ethics Principles in influencing governmental policy remains limited (Rességuier & Rodriques, 2020, p. 3). Clear shifts in policy directly attributed to AI Ethics Principles are rare, such as specific textual references in policies or the implementation of actions based on relevant recommendations. The slow pace of governmental policymaking may account for the limited impact, especially as most AI Ethics Principles were published within the past two years. Alternatively, the current versions of AI Ethics Principles may not have fully lived up to their potential in shaping governmental policymaking (Stix, 2021, p. 5).

Considering these aspects, the OECD emphasizes that policymakers must ensure that AI contributes to meeting global sustainability targets and address five measurement gaps with policy implications. Firstly, establishing measurement standards for sustainable AI is necessary, facilitating informed policy decisions through consensus on terminology, standards, indicators, and reporting requirements (OECD, 2021, p. 5). Expanding data collection on the environmental impacts of AI computer and applications at national, firm, and AI model levels is crucial, incorporating sustainability metrics such as GHG emissions, energy consumption, water usage, and resource utilization. Distinguishing AI-specific measurements from general-purpose computers remains challenging, requiring efforts to disaggregate ICT infrastructure datasets and develop tailored metrics for AI technologies. This detailed data collection is essential for informing effective regulatory frameworks and sustainability initiatives addressing the specific environmental impacts of AI technologies across diverse sectors and contexts. Refining data collection methodologies and utilizing innovative approaches are imperative to capture the unique environmental footprint of AI systems compared to conventional computing infrastructures.

Lastly, the OECD calls for enhancing environmental transparency and equity globally, focusing on promoting sustainability across a wider range of national contexts and sharing information and best practices to address negative impacts, particularly in emerging economies (OECD, 2021, p. 6).

Understanding the broader environmental impacts of AI/ML beyond operational energy use and GHG emissions is essential for developing comprehensive sustainability strategies. This includes considering the environmental footprint of AI technology throughout its lifecycle, from production and transportation to end-of-life management. Production processes involve resource-intensive activities like mining for rare earth minerals, which contribute to carbon emissions and habitat destruction. Transportation of AI components add to the environmental impact through fuel consumption and emissions. Proper disposal and recycling of AI hardware at the end of its lifecycle are also essential to minimize e-waste and associated environmental risks. Moreover, AI's energy consumption and resource demands can impact biodiversity and contribute to exceeding planetary boundaries, highlighting the need for holistic assessments and sustainable practices across all stages of AI technology development and use.

5. Concluding Remarks

The increasing usage of AI/ML has notable environmental impacts. These include habitat disruption and degradation due to automation and the energy-intensive nature of these technologies, which contributes to increased carbon emissions and resource depletion. Addressing these challenges requires a holistic approach that integrates sustainability considerations into automation strategies to mitigate adverse environmental effects and promote responsible technological development.

This institutional analysis outlined the current landscape for sustainability and AI/ML regulations at the international and EU levels. International law sets the stage for AI/ML regulation through initiatives like the OECD AI Principles and the Council of Europe's forthcoming AI Convention. The OECD AI Principles, established in 2019, promote ethical AI development focusing on inclusive growth and sustainability, emphasizing the responsible stewardship of AI to protect the environment, but lacks enforceability. The AI Convention aims to create a binding framework emphasizing human rights, democracy, and environmental protection, showcasing a commitment to sustainable and ethical AI governance on a global scale. On the other hand, the EU has taken a proactive approach in this realm since the establishment of the Guidelines for trustworthy AI, grounded in lawfulness, ethics, and robustness, as outlined in the 2019, that pointed out as one of the seven requirements the societal and environmental well-being. The AI Act, anticipated to become EU law in 2024, builds on these principles, incorporating a risk-based approach to ensure fundamental rights and the ethical development of AI. It highlights sustainability by promoting energy-efficient AI systems and encouraging environmental responsibility, aligning with the EU's long-standing commitment to sustainability evident in policies like the European Green Deal and the EU Climate Law. Despite sparse mentions, the Act underscores the importance of integrating environmental considerations into AI governance.

It becomes evident that in the evolving regulatory landscape for AI must broaden its focus to include environmental impacts such as digital waste and resource utilization. Addressing these challenges requires proactive policymaking that balances innovation with sustainability. Current efforts, like the EU's balanced approach, show promise, but there is a growing need for robust regulation to ensure long-term viability and public trust. Sustainable AI governance should integrate environmental considerations into design and development, emphasizing interdisciplinary collaboration to achieve global sustainability targets and safeguard both the environment and human well-being.

Addressing the environmental impacts of AI technologies is critical for ensuring their sustainable development and deployment. Policymakers must integrate sustainability principles into AI regulations, emphasizing energy efficiency, transparency, and responsible resource utilization. The EU AI Act represents a significant step in this direction, setting a precedent for comprehensive and adaptable regulation. By fostering collaboration among stakeholders and prioritizing holistic, regulatory frameworks must comprehensively address the environmental impacts of AI, such as digital waste and resource utilization. Policymakers must prioritize the development of coherent and effective regulatory measures that align with global sustainability targets, ensuring a harmonious balance between technological advancement and environmental stewardship in the digital age.

This study emphasized the dynamic interaction between formal regulations and informal factors, highlighting the importance of comprehensive frameworks that align with broader societal goals, but it is not conclusive. While this research provides useful insights, it is limited to the analysis of AI regulation at the international and European levels. More research is needed, especially to investigate the specific environmental and social effects of AI in different sectors and jurisdictions. Further studies could not only expand this scope but also work more decisively towards placing the questions tackled at the top of the European research agenda.

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