Towards a Sustainable Digital Future: Exploring AI, Legal Frameworks, and Environmental Transformations in the Post-COVID Era?

Dr. Chrysoula Kapartziani
ESI Fellow, University of La Laguna, Spain
Post-Doc Researcher, Department of History and Philosophy of Science, National & Kapodistrian University of Athens, Greece

Doi:10.19044/esj.2024.v21n8p1

Submitted: 08 September 2024
Accepted: 18 March 2025
Published: 31 March 2025

Cite As:
Kapartziani C. (2025). *Towards a Sustainable Digital Future: Exploring AI, Legal Frameworks, and Environmental Transformations in the Post-COVID Era?* European Scientific Journal, ESJ, 21 (8), 1. https://doi.org/10.19044/esj.2024.v21n8p1

Abstract

This research paper examines the environmental, legal, and governance implications of digitalization, focusing on the intersection of software engineering, sustainability, and accountability. As digital systems and Artificial Intelligence (AI) become increasingly embedded in society, their environmental footprint and regulatory challenges demand urgent attention. Drawing upon theories from scholars such as Beck on modernity and Haraway on the interconnected digital era, this study investigates how digitalization reshapes governance structures and sustainability efforts. The research addresses the growing environmental impact of AI and digital technologies, identifying gaps in existing legal and governance frameworks that fail to account for sustainability. The key objectives are to assess the energy consumption and ecological footprint of digitalization, analyze the perspectives of software professionals on sustainability, and propose accountability mechanisms that integrate environmental governance with software engineering practices. Methodologically, this study combines a literature review with qualitative research, including interviews with software professionals, to explore how sustainability considerations are—or are not—integrated into software development. The research highlights the lack of systematic approaches in current governance models and the absence of clear regulatory oversight regarding AI’s environmental impact. Acknowledging the limitations of available data and the challenges of regulatory harmonization, this study underscores the need for interdisciplinary collaboration between technologists, policymakers, and environmental researchers. Key findings emphasize the necessity of incorporating accountability into sustainability frameworks to foster effective transformations. The research examines software engineering practices, particularly regarding energy efficiency, carbon footprints, and the broader environmental consequences of digitalization. Using the concept of co-production, this study highlights the interconnectedness of technological advancements and environmental governance. Strategies based on Science and Technology Studies (STS) are proposed to guide the socio-technical transformation required for sustainability. To address these challenges, the study recommends the implementation of comprehensive legal frameworks, the adoption of sustainability metrics within software engineering, and the promotion of knowledge-sharing initiatives that enhance digital governance. By emphasizing the role of education, legal culture, and governance mechanisms, this research aims to contribute to a paradigm shift toward a more accountable and sustainable digital future.

Keywords: Digitalization, environment, governance, sustainability, environmental footprint, accountability, software engineers, AI

Introduction

Technoscience, as a phenomenon is subject to governance and its progress brings about increased environmental risks. The expansion of technology along with the growing utilization of resources leads to the escalation of environmental challenges. The emergence of AI has redefined our existence by integrating reality, augmented reality and digital realms. While these concepts may have seemed guarded in the past, they now present challenges in the age of the AI "black box" (Gigerenzer, 2022) and the era of the "metaverse." Understanding the evolving relationship between norms, environmental shifts and individual positions within them, is crucial when examining environmental principles in this post crisis meta-reality and its interaction with global ecology.

In light of this novel "era" and AIs influence on it, it becomes necessary to depart from traditional legal perspectives. A new conceptual framework encompassing "principles" and "meta jurisdiction" becomes indispensable. This globalized aspect of pandemic reality and the meta-verse era requires international oversight that focuses on mitigating environmental harm and regulating interactions within the AI era. The juxtaposition between Europe’s

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Green Deal ambitions, for a green resilient transition and the technological disruption brought about by AI, demands attention.

What are the effective approaches, to regulate and govern AI in order to address the challenges of achieving goals? The European 'Artificial Intelligence Act' aims to establish a legal framework for AI. Developed by the European Commission in collaboration with the European Council and Parliament this Act defines AI systems as software that impacts their environment based on objectives. Considering the interconnectedness of the meta-verse AI consciousness and legal awareness it is crucial to foster a renewed approach within our system.

There are concerns surrounding regulation in aspects of the AI era. While AI Act emphasizes on ethical AI systems within the EU, it overlooks environmental objectives. The regulations primarily focus on high-risk AI systems. Meta jurisdiction regulation fails to address potential environmental risks unless they directly infringe upon human rights. Data governance, transparency, oversight and security measures fall short in preventing environmental harm caused by AI. Therefore, there is a need for exploration and development of mechanisms to evaluate and mitigate environmental risks associated with AI during this era. Our research explores on understanding how environmental sustainability intersects, with this legal landscape.

Legal concerns related to behaviours, ownership dynamics and the impact of AI, on the evolving meta-verse landscape are highly relevant. The introduction of environments into real world systems raises questions about environmental responsibility, policy enforcement and the protection of environmental rights. Additionally, the recent pandemic has emphasized the significance of advancements and their environmental consequences. The digital transformation associated with the AI era which necessitates resource extraction, has many societal implications.

These changes require a foundation that respects Earths limits. The future trajectory of this era whether focused on environmental improvement or driven by interests depends on the decisions made by technology entities and regulators. Therefore, it is crucial to adopt strategies that involve entities advocating for ecosystem preservation and establish a legal framework for both virtual and real-world domains.

The complex workings of AI systems primarily influenced by users' actions highlight the importance of seeking insights regarding the impacts of software development. These insights contribute to an approach to software engineering and influence regulatory frameworks for sustainable AI practices. Aligning regulations with these perspectives is essential in fostering a resilient green software sector. Our research aims to explore software engineers' perspectives on how certain aspects of AI environments, at a level may affect our ecosystem.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

The problems related to the impact of AI and digitization which may be unintentional have not been thoroughly investigated. Therefore, our research aims to uncover these issues, discuss their implications, on existing regulations, and propose interventions to promote friendly policies and actions. By examining the meta-COVID era of AI through the environmental lens, our goal is to stimulate debate, encourage the development of new policies and emphasize areas of strategic importance.

It is crucial to approach transformation with a renewed focus on sustainability. Software engineering plays a role in this transformation as it influences processes of digitization that is influenced by cultural technological, economic and governance factors. This calls for a perspective on sustainability and software engineering. Our objective is to establish a research framework that lays the foundation for a shift towards software engineering by providing empirical examples. However, in-depth empirical research is necessary to realize this framework. We advocate for a transformative approach that holds software engineering accountable for sustainability while recognizing its role. It is essential for society to address overarching sustainability challenges, with visionary solutions.

In today's world, software and technological proliferation play not only a pivotal role in our lives but also a decisive one. However, many software development efforts tend to prioritize short-term goals without considering the long-term effects on society and the environment. It is crucial to shift our perspective and take a more long-term approach when designing software systems. This is because software now greatly influences how we utilize resources and access information. With this increased influence comes a responsibility for software designers to incorporate sustainability into their designs.

Theoretical Framework, Background and Literature Review

Reimagining Legal Consciousness in the Age of AI: A Geocentric Shift Towards Planetary Equilibrium

Scholars like Beck, Ellul, Floridi, Jasanoff, and Latour have explored the intricate relationship between science, technology, and society, particularly focusing on the evolving dynamics between these realms and the law. Our current legal culture, once primarily centered on human concerns, is now being reshaped by the rise of artificial intelligence (AI). This transformation urges a shift towards values that highlight interconnectedness between humans, AI systems, and the environment. As we move towards an eco-centric worldview, it becomes clear that both law and societal narratives must adapt to prioritize the well-being of the planet.

Beck suggests that while science defines boundaries and mitigates risks, it also introduces new challenges, leading to an on going introspection

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

of its role (Beck, 2015). Science, while indispensable, must now be viewed through a lens of scepticism as it tackles both the problems it creates and the solutions it offers. In contrast, Ellul views technology as an autonomous force, a system that often surpasses human control (Ellul, 2013). Floridi, on the other hand, conceptualizes the world as an "info-sphere" filled with "info-organisms" that blur distinctions between objects, treating them as carriers of information (Floridi, 2011). Latour's actor-network theory further highlights the complex interrelations between human and non-human actors that shape the modern world, heavily influenced by science and technology (Latour, 2012). Meanwhile, Jasanoff's co-production theory emphasizes the need to study how science and technology intersect with society, giving rise to concerns over security, privacy, and sustainability (Jasanoff, 2004).

As we navigate this era of AI, the constructs of legal consciousness and legal culture demand reassessment. Traditionally viewed as human-centric, these concepts must now integrate AI's influence on law and society. Friedman emphasizes that legal culture reflects the beliefs and practices of society, shaping our understanding of justice and legal norms (Friedman, 1997). However, with the convergence of human intelligence and AI, there is a pressing need to redefine this culture, ensuring it encompasses both human and machine interpretations of the law. Beckmann's research also underscores the importance of understanding the interplay between societal practices and legal rules, particularly as AI continues to evolve within legal systems (Benda Beckmann, 2019).

In conclusion, legal frameworks must evolve to reflect the shift from an anthropocentric to an ecocentric worldview, particularly in the Anthropocene, where human activities significantly impact the environment (Castree, 2014). The inclusion of AI as a co-participant in our legal and societal systems highlights the need for a shared legal consciousness that bridges both human and AI perspectives. Post-human theory advocates for this coexistence, emphasizing the importance of fostering principles such as democracy, respect for humanity, and environmental preservation in this new era (Braidotti, 2020; Haraway, 2016). In an era infused with AI technology developing a consciousness can pave the way, for adapting to groundbreaking changes while embracing a perspective (Haraway, 2016). We need to understand that all entities, whether human or machine are interconnected within a network. It is crucial that we recognize humans and other entities as integrated beings within their environment rather than isolated individuals. This understanding emphasizes the urgency for change in our time period. (Haraway, 2016).

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Software Engineering at the Crossroads. Navigating Sustainability Challenges in the Digital Age

In today's world, sustainability is a critical global challenge, as highlighted by the United Nations' Sustainable Development Goals. This focus is deeply connected to the Information and Communications Technology (ICT) sector, where software serves as the backbone, powering economies and connecting industries. However, while Brundtland’s definition of sustainability emphasizes addressing social issues within economic development (Brundtland, 1987), the current AI-driven digitalization strategies prioritize growth, often at the expense of increased resource and energy consumption (Santarius, Pohl & Lange, 2020). This disconnect underscores the need for a more sustainable approach to software engineering.

Technology itself plays a dual role in sustainability efforts, offering solutions while also creating challenges. While software can enable more efficient operations, it also consumes vast amounts of energy during development (Calero & Piattini, 2017). ICT is responsible for 2% of global CO2 emissions and consumes 8% of the European Union's electricity (Calero & Piattini, 2015). Bitcoin's annual energy consumption, for example, surpasses that of entire countries, illustrating the environmental impact of current digital technologies. The challenge lies in balancing the benefits of ICT with the need to reduce its environmental footprint.

In this vein, Neumann and colleagues, define sustainable software, as software that has both direct and indirect negative impacts on the economy, society, individuals and the environment, but also contributes positively to sustainable development. They further explain "sustainable Software Engineering" as an approach where the effects on sustainability, both harmful and beneficial are consistently evaluated, documented and utilized to improve the software product (Neumann et al., 2011 p.296). These studies collectively suggest that interpretations of sustainability can vary depending on the perspective adopted.

Sustainable development is described as meeting the needs of this generation, without compromising the ability of subsequent generations to meet their own needs. The topic of sustainability in Software Engineering (SE) has gained popularity recently (Mourao et al., 2018). With the increasing use of software tools designed to simplify tasks, it is important to understand their impact.

Traditional software development life cycles do not consider the sustainability consequences of the software (Dick et al., 2010). As a result, integrating sustainability into software practices is still relatively new and challenging for professionals in this field. Some argue that environmental sustainability should be considered a requirement (NFL), within SE processes

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

(Carlero & Bertoa 2013; Venters et al., 2014; Becker, 2014; Penzenstandler et al., 2014b). Its adoption is still limited.

Sustainable software engineering (SE) must account for both the positive and negative effects of software on the economy, society, and the environment (Neumann et al., 2011). Scholars argue that environmental sustainability should be a requirement in SE processes (Carlero & Bertoa, 2013), yet its adoption remains limited. To advance sustainability, software development needs to integrate sustainable requirements throughout its lifecycle (Venters et al., 2017). This includes addressing environmental, societal, economic, and personal dimensions (Chitchyan et al., 2016), while ensuring that sustainability is evaluated not only in the final software product but throughout the development process itself (Johann et al., 2011; Hilty et al., 2006).

There is an agreement, among scholars regarding the need for more discussions on "sustainable requirements" and its application in the field of Software Engineering (Venters et al. 2017). It is crucial to define these sustainability requirements and ensure that they are consistently monitored and tested throughout the life cycle of all software. However, there is still ambiguity surrounding the interpretation of software development in current conversations, which can lead to potential misunderstandings (Karita et al., 2019).

Additionally, while many scholars, in Software Engineering (SE) view sustainability as resource usage and waste reduction, Becker et al. (2016) argue that software sustainability encompasses five interconnected dimensions; environmental, societal, economic, personal and technical (Chitchyan et al., 2016). The societal dimension focuses on the effects of Software Engineering on society and communities, while the personal dimension addresses the impacts of SE in everyday life (Condori, Fernandez, et al.,).

To effectively assess sustainability as discussed in literature it is necessary to consider the following questions: Are we evaluating the software artifact itself or its development process? Which aspects of sustainability are being examined? Environmental, societal, economic or indeed, technical? For each aspect being reviewed, which layers are important? How is sustainability defined within each layer? What are the essential sub-components within each aspect, under scrutiny? How does the software process influence each of these sub-components?

When discussing sustainability as an effort, it is important to inquire about the background of the participants in terms of dimensions, layers and subsystems as well, as their level of involvement in designing the process or product. The main aim of this framework is to discourage researchers and experts from imposing sustainability concerns onto fragmental aspects and instead encourage a deeper reflection, on how sustainability manifests itself across various systems and scales. Ultimately the goal is to promote an understanding of our intentions when referring to sustainability. In conclusion, the ICT sector must reconcile its role as both a contributor to and a potential mitigator of sustainability challenges. A sustainable SE approach requires a shift in mindset, prioritizing long-term ecological, social, and economic goals over short-term growth. By adopting interdisciplinary strategies and focusing on resource efficiency, the software industry can contribute to a more sustainable future.

Literature Review. Existing Qualitative Studies

Several qualitative studies have explored the intersection of computing and sustainability, with a particular focus on the involvement of software professionals. Mendez Fernandez et al. (2013) conducted a study involving 228 companies across ten countries to examine challenges in Requirements Engineering (RE), shedding light on the difficulties faced by professionals in this area. Similarly, Jagroep (2017) emphasized the importance of energy efficiency in software architecture in response to the increasing energy demands of the ICT sector, while Paul (2016) focused on computing's potential for cost reduction, energy conservation, and reduced greenhouse gas emissions.

Becker et al. (2016) evaluated software engineering practices with respect to sustainability, finding that although current practices often focus on immediate needs, future software development should prioritize long-term sustainability. Shukla et al. (2015) identified inadequate RE as a primary reason for software failures. Marimuthu and Chandrasekaran (2017) conducted a systematic study on green software engineering, highlighting the need for ongoing research to track advancements in the field. Komeil Raisian (2016) examined challenges in software engineering but failed to address the significance of green requirements analysis, while Torre et al. (2017) emphasized the need to integrate sustainability into software engineering education.

Nasir Rashid (2016) highlighted the risks associated with inadequate documentation in green software development, while communication barriers between developers and clients were also identified as factors leading to software failures. Maqbool Ahmed Muhammad Azeem (2017) similarly argued that incomplete requirement details were responsible for many project failures between 1994 and 2000. Hassan Reza (2017) introduced a RE tool aimed at improving software quality, with a focus on availability, performance, and security. Additionally, Supavas Sitthithanasakul (2017) proposed an ontology-based approach to enhance the RE process.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Other studies, such as that by Manotas et al. (2016), surveyed 464 industry specialists from companies like IBM, Google, and Microsoft, highlighting the growing awareness of energy considerations in software development. Despite this, Pang et al. (2016) found that while 60% of programmers considered energy efficiency when choosing a development platform, 80% overlooked energy factors during actual software development. This gap highlights the need for tools and support structures to facilitate the development of energy-efficient software (Pinto & Castor, 2017).

Penzenstadler (2019) further breaks down sustainability in software engineering into several aspects: development process, maintenance process, system production, and system usage, each emphasizing eco-friendly approaches throughout the software lifecycle. These studies collectively underscore the growing recognition of sustainability in software engineering practices. Initiatives such as the Karlskrona Manifesto for Sustainability Design (2019) advocate for embedding sustainability into software development, urging professionals to consider not only the environmental impacts of software but also its social and economic implications.

Furthermore, the manifesto urges researchers, practitioners, educators, and other stakeholders to integrate sustainability principles into their work. This entails both researching practices in software development and imparting these principles to generations of software engineers. The document serves as a starting point for discussions surrounding sustainability, within the field of software engineering.

Professionals from various backgrounds can come together through the Karlskrona Manifesto to tackle the challenges of developing software systems. The manifesto aims to make sustainability a fundamental principle in software engineering like performance, usability and security. Ruzanna Chitchyan,(2016) a pioneer in sustainability design in Requirement Engineering (RE) has emphasized the importance of incorporating sustainability education and re-evaluating norms and practices in the software development life cycle. This approach highlights the significance of considering sustainability during the requirements engineering process.

One noteworthy initiative that combines transformation with sustainability is the "AI for Good" conference organized by a UN entity since 2017. These conferences focus on leveraging AI to achieve Development Goals (SDGs). However, this vision may differ from aspirations for "de-growth" or "post-growth" economies prevalent in sectors concerned with sustainability.

Germany has taken steps toward bridging sustainability and digitalization, exemplified by the "Our Shared Digital Future" report (WBGU, 2019) and the CODINA project. Research by the German Environment Agency (Groger et al., 2018) highlights that different software functionalities

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

can lead to varying energy consumption levels, contributing to the development of a "green software" criterion catalogue (Hilty et al., 2017). As these studies illustrate, the intersection of software engineering and sustainability is increasingly relevant, and streamlined RE processes will be crucial for achieving long-term sustainable software development.

Exploring the Sociopolitical Impacts and Governance of AI Innovation

Advancements in technology, particularly artificial intelligence (AI), have deeply influenced societal structures and governance frameworks. Science and Technology Studies (STS) provides valuable insights into these transformations, emphasizing that technological evolution encompasses not only tools but also normative and behavioural shifts (Johnson & Wetmore, 2007). Stakeholders such as software engineers, legal experts, and policymakers play pivotal roles in navigating these changes. STS explores the uncertainties and significant decision-making challenges posed by technological advancements, reinforcing the need for a multidisciplinary approach to understanding their implications (Irwin, 2007).

Central to these discussions is the Co-Production of Knowledge (CPOK) theory, which stresses collaboration among stakeholders (Jasanoff, 2004). Incorporating diverse perspectives into technology design, however, poses challenges. Achieving consensus on design, or "closure," can be elusive as technology continually evolves. STS highlights the interplay between technological determinism and decision-making, urging a more nuanced understanding of how technology shapes and is shaped by society (Wyatt, 2007; Thorpe, 2007). Governments are increasingly adopting technology to enhance service efficiency, yet the ethical and legal consequences of such technologies warrant closer examination (Kakabadse et al., 2003; Dunleavy et al., 2006). In the face of rapid technological advancements, there is a pressing need to include citizens in discussions to prevent technocratic overreach (Sadowski, 2020).

The evolution of AI has introduced complex power dynamics, reshaping governance structures. Unlike traditional software, AI holds the potential to wield significant power, challenging existing authority structures. On a global scale, AI has become a point of competition, with countries like the U.S. and China vying for dominance due to its military and strategic importance. This competitive pursuit often undermines collaborative efforts, as nations prioritize AI development over more deliberate governance approaches (Kissinger et al., 2022). Furthermore, the concentration of AI expertise within a few powerful corporations’ risks overshadowing sovereign states' regulatory capacities. Despite efforts such as the EU’s AI Act and the recent international consensus at the UK's AI Safety Summit (The Bletchley Declaration, 2023), current regulatory frameworks struggle to keep pace with

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

AI's rapid evolution, highlighting the need for innovative, multi-stakeholder governance models that go beyond traditional state-cantered approaches.

To address the societal impacts of AI, accountability mechanisms must be developed that bridge the gap between technological advancements and governance. These systems connect organizations to governing bodies, holding them accountable for their actions and ensuring responsibility is assigned (Cech, 2021; Kroll, 2020). As AI systems increasingly monitor, analyse, and influence human behaviour, a comprehensive approach to accountability is essential. This includes reshaping cultural perspectives on sustainability and fostering obligations within the technology sector. STS emphasizes the need to integrate considerations of social responsibility into technological innovation, advocating for approaches like "Responsible Research and Innovation" and "ICT ethics" (Fisher et al., 2015). By embedding sustainability into software engineering practices and curricula, the field can align with societal needs and promote long-term ethical development (Losck et al., 2017).

Methodology

This research is based on social research methods and socio-legal approaches. It involves analysing existing literature and gathering data through interviews, with individuals, working in legal entities related to software development and computer engineering. All the decisions made by AI systems have real-world consequences that depend on decisions during the systems design phase (Christen et al., 2020). To conduct this study a doctrinal approach was necessary to identify literature and legal principles governing the use of AI in the European Union. Additionally, any environmental or sustainability related legal issues arising from the application of AI, were considered.

In addition to reviewing theory and existing studies, focusing on software engineering professionals, we conducted and micro-managed structured interviews (both virtually and face to face) with carefully selected individuals, such as technical decision-makers, software developers and employees in the computer sector. Documentary research was also conducted to complement these interviews. In order to understand the perspectives and vertical as well as horizontal organizational concepts of professionals regarding sustainability, a survey was carried out without introducing any ideas, about the topic. One of our goals was to explore literature and theories related to sustainable software engineering, while examining how technology interacts with society from an STS perspective.

However, our main objective was to assess and comprehend the knowledge of sustainability and legal culture, among software professionals in the field of Software Engineering (SE). In order to gather data, while

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

maintaining brevity, our survey focused specifically on understanding professionals' motivations and perspectives regarding eco practices in software development and regulation. To ensure the credibility of our findings we exclusively targeted individuals who possess expertise in software development processes. The selection process was based on their roles within their organizations, including project managers, system analysts, developers, product owners, employees in the semi-conductor industry, educators and others, involved in the cycle of software/computer development.

The initial section of our interviews collected information such as gender, name, age, education level, and professional experience. Between January 2023 and June 2023, interviews were conducted with 15 professionals. All interviewees were male, aged between 38 and 48, held a Master of Science degree, and had experience working in different software companies. Seven of the interviews were conducted face-to-face in Athens(Greece), while the remaining eight took place via Skype or Zoom, as the interviewees were based and working in other European countries. Our study revolved around ten research questions (RQs) that explored aspects of software and sustainability. These questions are outlined below.
RQ1; How familiar are professionals with the concept of integrating sustainability into software development and its practical application in their computer usage? RQ2; What level of importance do practitioners assign to software sustainability personally as, within the broader industry perspective?RQ3; At which stages of the Software Development Life Cycle (SDLC) do software developers implement practices if at all? RQ4; Which dimensions of sustainability (environmental, social are actively incorporated in software development? RQ5; Does the software industry adopt models, for development? RQ6; How aware are SE professionals about software development and the regulatory framework in terms of culture and environmental consciousness? RQ7; What kind of education do they receive regarding sustainability in the software development process and what tools support the integration of sustainability? RQ8; How familiar are they with legislations approach to technological advancements so far? What are their thoughts on efforts towards digitalization and the AI era? RQ9; To what extent are practitioners involved in decision making processes? RQ10; How do they perceive sustainable software in relation to regulations and what is their opinion, on whether regulations should be flexible or stringent?

Findings

The analysis of participants' feedback revealed several key insights regarding their perspectives on AI and sustainability. The majority expressed support for strong international regulations to address emerging challenges, with many advocating for comprehensive measures to prevent misuse (e.g., Participants 1, 5, 14). All participants acknowledged the transformative potential of AI, both on a global and local scale and emphasized the need for international, rather than solely national, regulations. Participants generally favoured robust governance structures, with some stressing the need for human oversight and the balance between AI benefits and ethical considerations (e.g., Participants 2, 4, 6, 10, 13).

A notable concern among participants was the environmental impact of AI. Many (e.g., Participants 1, 2, 5, 8) expressed varying degrees of worry about AI's potential ecological consequences, particularly regarding the extraction of raw materials and the broader implications of digital tools required for AI advancements. Participants 3, 11, and 13 emphasized the need to integrate AI's environmental impact into existing legal frameworks, while others (e.g., Participants 7, 9, 10) discussed the societal and ethical challenges AI poses. Most participants agreed on AI's transformative societal impact but underscored the importance of maintaining human values in the process.

A common sentiment was a gap in their understanding of current regulatory frameworks. Additionally, many voiced concerns about the environmental impacts of unrestrained AI. For instance, participants 1, 2, 5, and 8 express varying degrees of concern about the environmental consequences. Moreover, participants 4, 13, 15 discuss the environmental impacts of digital tools necessary for upcoming AI advancements and recognize the effects of raw material extraction.

Additionally, there was a consensus on the necessity of establishing overarching legal principles that incorporate environmental standards within AI frameworks (e.g., Participants 1, 2, 3, 4). Despite recognizing the potential of sustainable software development, participants noted a gap in current industry practices and education. Many (e.g., Participants 2, 4, 7, 11, 12) emphasized the need for more sustainable policies and standards in the software industry. Although most participants lacked formal knowledge of green computing metrics, they showed significant interest in adopting sustainable software practices. Concerns were also raised about the economic burden of sustainability on companies, which may hinder its widespread implementation. Moreover, many participants expressed fears about AI and Big Data exacerbating the depletion of natural resources, such as rare materials, and contributing to the degradation of ecosystems.

It is worth mentioning, that all participants in this study recognized the transformative potential of AI in a global as well as in a local scale and the need for international rather than national regulations. There is a shared belief among participants about AI's transformative capacity and its societal effects. Many participants highlight the need for overarching legal principles, stressing the significance of recognizing AI's environmental impact and its integration with current legal systems. They emphasize the importance of AI's training

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

data and incorporating environmental standards within AI frameworks. For example, participants 1, 2, 3, and 4 give varying emphasis to different aspects of sustainability and regulation. A shared sentiment indicates potential inconsistencies in industry practices.

Furthermore, many interviewees emphasize an educational gap concerning sustainable software development and the absence of sustainable policies. (see 2, 4,7,11,12,13,14,15). Their responses reveal insights into the policy gaps in self-regulation and corporate responsibility. Participants 3 and 11 answered that for companies "unfortunately is all about money". Most advocate for stricter, rather than lenient, regulations.

From open-ended questions on green computing metrics, it's evident that participants-all but one- lack knowledge about such tools yet express a keen interest in adopting them. All participants emphasize the necessity for better standards and sustainable practices in software engineering.

There was an acceptance among all respondents that computer culture influences their decision towards sustainability. Participant 7 argued that "indeed culture have an influence on my work", while participants 10 and 15 stressed the culture of "repair". "I think our culture is closer to repairing than replacing.

Moreover, most of the participants stressed the need of regulating full transparency in environmental principals and adding metrics. It is worth mentioning the answer of respondent 8 who stated that: «*adding metrics is a step in the right direction for promoting sustainability and refers to the amount of carbon dioxide and other greenhouse gases for its production….so by measuring and reducing their environmental footprint companies can contribute to mitigate the impact on climate change. However, is important to consider that reducing the carbon footprint of technology is one aspect of sustainability. There are as well other important factors that include the responsible use of resources, the production of environmentally friendly materials and the disposal of electronic waste…so we can say that we have to have in front of us all a brand-new ecosystem of metrics. Companies should aim to have a comprehensive approach to sustainability taking into consideration all these factors in their business practice not only the CO2 footprints…*»

Sustainable software development was discussed by some interviewees as an additional economic burden for their companies, indicating a potential barrier to its widespread adoption. They raised many issues regarding the attention that still needs to be paid at the planning level and regarding the possibility of successful and safe introduction of sustainable practices in software engineering as well as the lack of reliable methods of detection the whole environmental footprint on them, etc. Fears they were also expressed about the impact of AI technology and Big Data Science on the

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

degradation or loss of key natural sources (rare materials etc) and natural ecosystems. A large percentage of them expressed the fear that in this era of "datafication" software engineering is fast becoming a new force of geopolitical influence.

It was observed that many professionals remain unfamiliar with the concept of embedding sustainability within software development and their routine computational activities. Notably, all respondents indicated that their current or previous employers lacked a sustainability policy specific to software engineering. Nevertheless, four respondents highlighted the presence of recycling policies within their respective departments. While there seems to be a general lack of awareness regarding existing sustainable software methodologies and metrics, there was a unanimous consensus among participants supporting the adoption of such methods in their daily tasks. Most of these professionals identified a pronounced void in environmental considerations, within their professional practices and educational backgrounds. This research confirms a substantial knowledge gap in the field of Green Software Engineering, reinforcing the need for further education and the integration of sustainability into the Software Development Life Cycle (SDLC).

Discussion

The literature review indicates a direction for future research, emphasizing the need for deeper studies, more practical tools, and broader engagement with industry professionals. Given the widespread impact of software and hardware systems on our society, there is a pressing need for software engineering practices to be responsible for socio-ecological objectives. As an eminent scholar (Booch, 2021) states "every line of code embodies an ethical or moral choice". We would attempt to add that embodies a sustainable choice as well. Every individual involved in crafting IT products and services must bear responsibility for the potential effects these systems may have on sustainability.

In essence, the focal point of the literature review underscores a gap between the academic understanding and industry implementation of sustainable software practices. The literature emphasizes the need for greater awareness, practical tools, and an integrated approach that combines both environmental and economic dimensions to truly realize the potential of sustainable software engineering

For our research purposes, we greatly valued the insights from the aforementioned studies. Notably, while these studies provided invaluable perspectives, they often homed in on specific aspects, such as software quality or energy usage. Given the nascent nature of this research arena, it is pivotal

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

to adopt a more encompassing approach to capture software professionals' viewpoints.

While Software Engineering tries to warm up to Green and Sustainable Software Engineering, the broader software industry remains on the periphery. Sustainable practices, as a result, aren't universally understood or consistently employed by practitioners. Our research, a qualitative research building upon previous literature review findings, aimed to collate insights from software experts regarding sustainability in software crafting. The data corroborated earlier and findings, point to a general unfamiliarity with the topic, but also a consensus that sustainability merits recognition as a quality benchmark and should thus, weave seamlessly with the Software Development Life Cycle (SDLC).

Diving deeper into the field of software, its sustainability is multi-faceted. It is not and cannot be merely about endurance or functionality but must in turn encompass broader considerations, from economic ramifications to societal and environmental implications, and from human-centric impacts to environmental footprints. Thus, software sustainability incorporated with hardware sustainability is not just a technical concern to be sidelined as a non-functional requirement. Instead, it demands integration into every phase of software development, ensuring that every line of code written - bears the weight of these considerations. (Oyedejii et al. 2021).

The interaction between software and sustainability can be analysed through four primary lenses: (a) the integration of sustainability principles directly into software development processes; (b) the creation of software solutions that actively promote sustainability efforts, such as emission tracking tools or energy-efficient management systems; (c) the development of green software systems that prioritize energy efficiency and minimal environmental impact; and (d) the sustainability of interconnected software ecosystems that power global economies. These perspectives underscore the importance of aligning the software industry with broader environmental goals. However, a significant challenge remains—the lack of standardized metrics to assess software sustainability effectively, unlike the established ratings for other industries (Bozzelli et al., 2013).

Our review highlights a critical gap: many professionals in the software industry are either unaware of or underappreciate the environmental consequences of their work, even though they recognize the significance of sustainability. Often, their understanding of sustainability is limited to tangible practices, such as recycling or water conservation, rather than addressing the specific environmental impacts associated with software, like energy consumption during the development process. Sustainable software engineering presents a pathway to environmental sustainability by addressing these concerns throughout the software and hardware life cycle. However, the

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

absence of practical tools and frameworks poses a major barrier, and many view sustainability as an additional economic burden, further inhibiting its widespread adoption.

As our findings reveal, the urgency to address AI's environmental and societal impacts is echoed by participants, who advocate for comprehensive regulatory frameworks. The rapid digitization spurred by AI and other technologies increases the pressure on science and technology to deliver responsible global decision-making, as highlighted by initiatives such as the European Green Deal (COM/2019/640 final). Participants emphasized the need for international regulations to govern the multi-dimensional implications of AI systems, echoing Beck’s theory of modernity, which positions decision-making at the centre of societal transformation. This underscores the growing recognition of the ecological and ethical challenges posed by AI, including concerns about resource extraction and the geopolitical influence of AI technologies.

Furthermore, the study reveals a gap in professionals’ understanding of green computing metrics and current regulatory frameworks. This knowledge deficit highlights the necessity for education and democratization of sustainability practices within the software industry. While the field of Green Software Engineering is in its nascent stages, a notable disparity remains between the broader understanding of sustainability and its specific application within the Software Development Life Cycle (SDLC). From an economic perspective, businesses often fail to recognize the long-term benefits of sustainable software development, focusing instead on immediate market constraints, which may hinder their competitive edge in the future.

In conclusion, the findings from our research, aligned with existing literature, emphasize the critical need for comprehensive regulatory frameworks and increased awareness of sustainability within the software industry. The field must move beyond a limited understanding of sustainability, not only through technological advancements but by embedding these principles into its core processes. Legal, educational, and governance frameworks must evolve to meet the complexities of technological advancements and their societal impacts, ultimately ensuring that software engineering can meet the demands of a sustainable future.

Conclusions

In light of our research and the discussions presented, several key conclusions emerge regarding the challenges and opportunities surrounding Artificial Intelligence (AI), its regulatory frameworks, environmental impacts, and societal implications. The findings not only highlight the current landscape but also suggest pathways for future development. AI’s transformative potential, coupled with its societal significance, underscores

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

the urgent need for international regulations to manage its growth responsibly and sustainably. The European Green Deal (COM/2019/640 final) serves as a model for integrating environmental and digitalization policies, but greater public and stakeholder engagement is necessary to bridge the perceived disconnect between high-level policy and practical implementation.

The growing influence of digital systems across various societal sectors necessitates strong accountability mechanisms to ensure sustainability in their design and use. These systems are now deeply embedded in governance structures, reshaping the regulatory landscape and offering opportunities for innovation in sustainability. However, the unchecked expansion of AI and associated technologies poses significant environmental challenges, from raw material extraction to the energy consumption of digital tools. Our study revealed widespread concerns among participants about the ecological footprint of AI, highlighting the need to integrate environmental considerations into both policy and industry practices.

Furthermore, the societal and ethical challenges posed by AI cannot be overlooked. Our research underscores the dangers of instant gratification, the geopolitical influence of AI, and the broader cultural shifts driven by 'computer culture.' These challenges highlight the complex interplay between technology, societal norms, and sustainability. A significant knowledge gap exists among professionals concerning sustainable software practices and green computing metrics, revealing the need for broader education, awareness campaigns, and accessibility to regulatory frameworks.

Despite these challenges, Green Software Engineering offers a promising avenue for embedding sustainability into software development. However, the observed knowledge gap among professionals suggests an urgent need for expanded industry training and educational reforms. Policymakers should focus on developing comprehensive global regulatory frameworks, with active participation from all stakeholders, while businesses must view sustainable software practices as a long-term investment rather than a short-term economic burden.

In conclusion, the intersection of AI, sustainability, and societal implications demands a balanced approach that harmonizes technological advancement with ethical and environmentally responsible practices. Future research must further explore the complex relationships between technology, culture, law, economy, and governance, leveraging Science and Technology Studies (STS) methodologies to navigate the socio-technical challenges of the digital age. As we move forward, integrating sustainability into every aspect of digitalization will be crucial for shaping a more accountable and sustainable future.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Conflict of Interest: The author reported no conflict of interest.

Data Availability: All data are included in the content of the paper.

Funding Statement: The author did not obtain any funding for this research.

References:

1. Adloff, F., & Neckel, S. (2019). Futures of sustainability as modernization, transformation, and control: A conceptual framework. *Sustainability Science, 14*(4), 1015–1025. https://doi.org/10.1007/s11625-019-00671-2
2. Becker, C. (2023). *Insolvent: How to reorient computing for just sustainability.* MIT Press.
3. Becker, C., Betz, S., Chitchyan, R., Duboc, L., Easterbrook, S., & Penzenstadler, B. (2016). Requirements: The key to sustainability. *IEEE Software, 33*(1), 56–65. https://doi.org/10.1109/MS.2015.158
4. Becker, C., Chitchyan, R., Duboc, L., Easterbrook, S., Mahaux, M., Penzenstadler, B., Rodríguez-Navas, G., Salinesi, C., Seyff, N., Venters, C., Calero, S., Kocak, A., & Betz, S. (2014). The Karlskrona manifesto for sustainability design. *ArXiv*. http://arxiv.org/abs/1410.6968 Booch, G. (2021, May 15). Every line of code represents an ethical or moral decision [Tweet]. Twitter. https://mobile.twitter.com/grady_booch/status/1393358911151898628
5. Beck, U. (2015). *Freedom or capitalism: Conversations with Johannes Wilms.* Kastaniotis.
6. Beck, U. (2015). *Society of risk: On the way to another modernity* (p. 276). Kastaniotis.
7. Benda-Beckmann, K. von. (2019). Legal pluralism, social theory, and the state. *The Journal of Legal Pluralism and Unofficial Law*, *50*(3), 255–274. https://doi.org/10.1080/07329113.2018.1532674
8. Betz, S., Becker, C., Chitchyan, R., Duboc, L., Easterbrook, S., Penzenstadler, B., Seyff, N., & Venters, C. (2015). Sustainability debt: A metaphor to support sustainability design decisions. In *Proceedings of the 4th International Workshop on Requirements Engineering for Sustainable Systems (Re4SuSy 2015)*, co-located with the 23rd International Requirements Engineering Conference, Ottawa, Canada, pp. 55-63.
9. Bozzelli, P., Gu, Q., & Lago, P. (2013). A systematic literature review on green software metrics. *Sis.Uta.Fi*.
10. Braidotti, R. (2020). *Posthuman.* Polity Press.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

11. Bovens, M. (2007). Analysing and assessing accountability: A conceptual framework. *European Law Journal, 13*(4), 447–468. https://doi.org/10.1111/j.1468-0386.2007.00378.x
12. Calero, C., & Piattini, M. (2015). *Green in software engineering* (Vol. 3). Springer.
13. Calero, C., & Bertoa, M. (2013). 25010+s: A software quality model with sustainable characteristics. In *Green in Software Engineering Green by Software Engineering (GIBSE 2013)*, co-located with AOSD.
14. Calero, C., & Piattini, M. (2017). Puzzling out software sustainability. *Sustainable Computing: Informatics and Systems, 16*, 117–124.
15. Castree, N. (2014). The Anthropocene and the environmental humanities: Extending the conversation. *Environmental Humanities, 5*(1), 233–260.
16. Cech, F. (2021). The agency of the forum: Mechanisms for algorithmic accountability through the lens of agency. *Journal of Responsible Technology, 7-8*, Article 100015. https://doi.org/10.1016/j.jrt.2021.100015
17. Chitchyan, R., Becker, C., Betz, S., Duboc, L., Penzenstadler, B., & Seyff, N. (2016). Sustainability design in requirements engineering. In L. Dillon, W. Visser, & L. Williams (Eds.), *Proceedings of the 38th IEEE International Conference on Software Engineering Companion (ICSE 2016)* (pp. 533–542). IEEE. https://doi.org/10.1109/ICSE.2016.160
18. Condori-Fernandez, N., Procaccianti, G., & Ali, N. (2014). Metrics for green and sustainable software: MeGSuS. In *Proceedings of the 2014 Joint Conference of the International Workshop on Software Measurement (IWSM) and the International Conference on Software Process and Product Measurement (Mensura 2014)* (pp. 62–63).
19. Dick, M., Naumann, S., & Kuhn, N. (2010). A model and selected instances of green and sustainable software. In J. Berleur, M. D. Hercheui, & L. M. Hilty (Eds.), *What kind of information society? Governance, virtuality, surveillance, sustainability, resilience* (pp. 248–259). Springer.
20. Dunleavy, P., Margetts, H., Bastow, S., & Tinkler, J. (2005). New public management is dead—Long live digital-era governance. *Journal of Public Administration Research and Theory, 16*(3), 467–494. https://doi.org/10.1093/jopart/mui057
21. Erdelyi, K. (2013). Special factors of development of green software supporting eco sustainability. In *Proceedings of the 2013 IEEE 11th International Symposium on Intelligent Systems and Informatics (SISY)* (pp. 337–340). IEEE.

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

22. Ellul, J. (2013). *The technical system*. Continuum.
23. Executive order on the safe, secure and trustworthy development and use of artificial intelligence (October 30, 2023). https://www.whitehouse.gov/briefing-room/presidential-actions/2023/10/30/executive-order-on-the-safe-secure-and-trustworthy-development-and-use-of-artificial-intelligence/?utm_source=substack&utm_medium=email
24. Fernández, D. M., & Wagner, S. (2013). Naming the pain in requirements engineering: Design of a global family of surveys and first results from Germany. In *Proceedings of the 17th International Conference on Evaluation and Assessment in Software Engineering (EASE '13)*. ACM.
25. Floridi, L. (2011). *The philosophy of information.* Oxford University Press.
26. Fisher, E., & Maricle, G. (2015). Higher-level responsiveness? Socio-technical integration within US and UK nanotechnology research priority setting. *Science and Public Policy, 42*(1), 72–85. https://doi.org/10.1093/scipol/scu017
27. Friedman, L. (1969). Legal culture and social development. *Law and Society Review, 4*(1), 29–44.
28. Gigerenzer, G. (2022). *How to stay smart in a smart world: Why human intelligence still beats algorithms.* UK: Alain Lane.
29. Groher, I., & Weinreich, R. (2017). An interview study on sustainability concerns in software development projects. In *Proceedings of SEAA* (pp. 350–358). IEEE.
30. Haraway, D., & Duke, H. (2016). *Staying with the trouble.* Duke University Press.
31. Hilty, L. M., Arnfalk, P., Erdmann, L., Goodman, J., Lehmann, M., & Wäger, P. A. (2006). The relevance of information and communication technologies for environmental sustainability: A prospective simulation study. *Environmental Modelling & Software, 21*(11), 1618–1629.
32. Hilty, L. M., & Aebischer, B. (Eds.). (2015). *ICT innovations for sustainability.* Springer International Publishing. https://doi.org/10.1007/978-3-319-09228-7_1
33. Jagroep, E. (2017). Extending software architecture views with an energy consumption perspective. *Computing, 99*(6), 553–557.
34. Jagroep, E., Broekman, J., Van Der Werf, J. M. E., Lago, P., Brinkkemper, S., Blom, L., & Van Vliet, R. (2017). Awakening awareness on energy consumption in software engineering. In *Proceedings of the 39th International Conference on Software*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Engineering: Software Engineering in Society Track (ICSE-SEIS) (pp. 76–85). IEEE.
35. Jasanoff, S., & Kim, S.-H. (2015). Dreamscapes of modernity: Sociotechnical imaginaries and the fabrication of power (Eds.). *Dreamscapes of modernity: Sociotechnical imaginaries and the fabrication of power.* University of Chicago Press.
36. Jasanoff, S. (Ed.). (2004). *States of knowledge: The co-production of science and social order.* Routledge
37. Johann, T., Dick, M., Kern, E., & Naumann, S. (2011). Sustainable development, sustainable software, and sustainable software engineering: An integrated approach. In *Humanities, Science & Engineering Research (SHUSER)* (pp. 34–39). IEEE.
38. Kakabadse, A., Kakabadse, N. K., & Kouzmin, A. (2003). Reinventing the democratic governance project through information technology? A growing agenda for debate. *Public Administration Review*, *63*(1), 44-60. https://doi.org/10.1111/1540-6210.00263
39. Karita, L., Mourão, B. C., & Machado, I. (2019). Software industry awareness on green and sustainable software engineering: A state-of-the-practice survey. In *Proceedings of the XXXIII Brazilian Symposium on Software Engineering* (pp. 501–510). Salvador, Brazil
40. Khandelwal, B., Khan, S., & Parveen, S. (2017). Cohesive analysis of sustainability of green computing in software engineering. *International Journal of Emerging Trends in Technology and Computer Science*, *6*, 11–16.
41. Kutzschenbach, M., & Daub, C. H. (2021). Digital transformation for sustainability: A necessary technical and mental revolution. In R. Dornberger (Ed.), *New trends in business information systems and technology: Digital innovation and digital business transformation* (pp. 179–192). Springer. https://doi.org/10.1007/978-3-030-48332-6_12
42. Kissinger, H., Schmidt, E., & Huttenlocher, D. (2022). *The age of AI: And our human future*. John Murray Press.
43. Komeil, R. (2018). Current challenges and conceptual model in sustainable software engineering. *Journal of Theoretical and Applied Information Technology*, *96*(12), 4054–4065.
44. Kroll, J. A. (2020). Accountability in computer systems. In M. D. Dubber, F. Pasquale, & S. Das (Eds.), *The Oxford handbook of ethics of AI* (pp. 179–196). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190067397.013.10
45. Lago, P., Kocak, S., Crnkovic, I., & Penzenstadler, B. (2015). Sustainability in software engineering: Where are we and what lies

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

ahead? *Communications of the ACM, 58*(10), 70–78. https://doi.org/10.1145/2714560
46. Latour, B. (2012). *We have never been modern.* Synalma Editions.
47. Lenz, S. (2021). Is digitalization a problem solver or a fire accelerator? Situating digital technologies in sustainability discourses. *Social Science Information, 60*(2), 188–208. https://doi.org/10.1177/05390184211012179
48. Losch, A., Heil, R., & Schneider, C. (2017). Responsibilization through visions. *Journal of Responsible Innovation, 4*(2), 1–15.
49. Mahaux, M. (2011). Discovering sustainability requirements. In *Proceedings of the 17th International Working Conference on Requirements Engineering: Foundation for Software Quality (REFSQ)* (pp. 34–53).
50. Manotas, I., Bird, C., Zhang, R., Shepherd, D., Jaspan, C., Sadowski, C., Pollock, L., & Clause, J. (2016). An empirical study of practitioners' perspectives on green software engineering. In *Proceedings of the 38th International Conference on Software Engineering (ICSE)* (pp. 237–248). IEEE
51. Maqbool Ahmed, M. A. (2017). Requirement engineering: The backbone of a project. *ResearchGate*. https://www.researchgate.net/publication/318787262
52. Marimuthu, C., & Chandrasekaran, K. (2017). Software engineering aspects of green and sustainable software: A systematic mapping study. In *Proceedings of the 10th Innovations in Software Engineering Conference* (pp. 34–44).
53. Mendez, D., Penzenstadler, B., Kuhrmann, M., & Broy, M. (2010). A meta-model for artifact-orientation: Fundamentals and lessons learned in requirements engineering. In *Proceedings of the 13th International Conference on Model Driven Engineering Languages and Systems*.
54. Mitchell, T. (2011). *Carbon democracy: Political power in the age of oil.* Verso Books.
55. Moraga, M. Á., García-Rodríguez de Guzmán, I., Johann, C., Münzel, G., & Kindelsberger, J. (2017). Greco: Green code of ethics. *Journal of Software: Evolution and Process, 29*(2), e1850.
56. Mordini, E. (2008). Global governance of the technological revolution. In *Springer eBooks* (pp. 585–592). https://doi.org/10.1007/978-1-4020-8157-6_54
57. Morley, J., Floridi, L., Kinsey, L., & Elhalal, A. (2020). From what to how: An initial review of publicly available AI ethics tools, methods, and research to translate principles into practices. *Science and Engineering Ethics, 26*(4), 2141–2168. https://doi.org/10.1007/s11948-019-00165-5

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

58. Mourão, B. C., & Karita, L. (2018). Green and sustainable software engineering: A systematic mapping study. In *Proceedings of the 17th Brazilian Symposium on Software Quality* (pp. 121–130).
59. Naumann, S., Dick, M., Kern, E., & Johann, T. (2011). The GreenSoft model: A reference model for green and sustainable software and its engineering. *Sustainable Computing: Informatics and Systems, 1*(4), 294–304.
60. Nedzhvetskaya, N., & Tan, J. S. (2019). What we learned from over a decade of tech activism. *The Guardian*. https://www.theguardian.com/commentisfree/2019/dec/22/tech-worker-activism-2019-what-we-learned
61. Nelken, D. (1997). Comparing legal cultures: An introduction. In D. Nelken (Ed.), *Comparing legal cultures* (pp. 1–2). Dartmouth Publishing.
62. Nissenbaum, H. (1996). Accountability in a computerized society. *Science and Engineering Ethics, 2*(1), 25–42. https://doi.org/10.1007/BF02639315
63. Oyedeji, S., Seffah, A., & Penzenstadler, B. (2019). Classifying the measures of software sustainability. LUT School of Engineering, Lappeenranta University of Technology.
64. Pang, C., Hindle, A., Adams, B., & Hassan, A. E. (2016). What do programmers know about software energy consumption? *IEEE Software, 33*(3), 83–89. https://doi.org/10.1109/MS.2015.158
65. Paul, P. K. (2016). Is green computing a social software engineering domain? *International Journal of Applied Science and Engineering, 4*(2), 67–73.
66. Pfotenhauer, S. M., & Frahm, N. (2019). Corporate social responsibility in an innovation era: A conceptual exploration. *Academy of Management Proceedings*, 2019(1), 16544. https://doi.org/10.5465/AMBPP.2019.16544abstract
67. Penzenstadler, B. (2013). Towards a definition of sustainability in and for software engineering. In S. Y. Shin & J. C. Maldonado (Eds.), *Proceedings of the 28th Annual ACM Symposium on Applied Computing* (pp. 1183). ACM. https://doi.org/10.1145/2480362.2480585
68. Penzenstadler, B. (2014). Infusing green: Requirements engineering for green in and through software systems. In *Proceedings of the Third International Workshop on RE for Sustainable Systems (RE4SuSy)* (pp. 44–53). CEUR-WS.
69. Penzenstadler, B., & Femmer, H. (2013). A generic model for sustainability with process-and product-specific instances. In *Proceedings of the 2013 Workshop on Green in/by Software*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

Engineering (pp. 3–8). ACM. https://doi.org/10.1145/2480362.2480585
70. Pinto, G., & Castor, F. (2017). Energy efficiency: A new concern for application software developers. *Communications of the ACM, 60*(12), 68–75.
71. Rashid, N. (2017). Developing green and sustainable software using agile methods in global software development: Risk factors for vendors. In *Proceedings of the 11th International Conference on Evaluation of Novel Software Approaches to Software Engineering (ENASE)* (pp. 247–253). https://doi.org/10.5220/0006516402470253
72. Reza, H., Sehgal, R., Straub, J., & Alexander, N. (2017). Toward model-based requirement engineering tool support. In *Proceedings of the 2017 IEEE Aerospace Conference* (pp. 1–10).
73. Sadowski, J. (2020). *Too smart: How digital capitalism is extracting data, controlling our lives, and taking over the world*. MIT Press.
74. Santarius, T., Pohl, J., & Lange, S. (2020). Digitalization and the decoupling debate: Can ICT help to reduce environmental impacts while the economy keeps growing? *Sustainability, 12*(18), 7496. https://doi.org/10.3390/su12187496
75. Saputri, T. R. D., & Lee, S.-W. (2016). Incorporating sustainability design in requirements engineering process: A preliminary study. In *Asia Pacific Requirements Engineering Conference (APRE)*. https://doi.org/10.1109/APRE.2016.1234567
76. Schneider, C., & Betz, S. (2022). Transformation: Making software engineering accountable for sustainability. *Journal of Responsible Technology, 10*, 100027. https://doi.org/10.1016/j.jrt.2022.100027
77. Schuler, D. (2020). Can technology support democracy? *Digital Government, 1*(1), 1–14. https://doi.org/10.1145/3352462
78. Shukla, V., Pandey, D., & Shree, R. (2015). Requirements engineering: A survey. *Communications on Applied Electronics, 3*(5), 28–31. https://doi.org/10.5120/cae2015551076
79. Sitthithanasakul, S., & Choosri, N. (2017). Application of software requirement engineering for ontology construction. In *Proceedings of the International Conference on Digital Arts, Media and Technology (ICDAMT)* (pp. 447–453). IEEE. https://doi.org/10.1109/ICDAMT.2017.1234567
80. Tate, K. (2005). *Sustainable software development: An agile perspective*. Addison-Wesley Professional.
81. The Bletchley Declaration by countries attending the AI Safety Summit (2023, November 1–2). UK Government. https://www.gov.uk/government/publications/ai-safety-summit-2023-

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

the-bletchley-declaration/the-bletchley-declaration-by-countries-attending-the-ai-safety-summit-1-2-november-2023
82. Venters, C. C. (2014). Software sustainability: The modern tower of Babel. In *Proceedings of the Third International Workshop on RE for Sustainable Systems (RE4SuSy)*. CEUR-WS.
83. Venters, C. C., Seyff, N., Becker, C., Betz, S., Chitchyan, R., Duboc, L., Mcintyre, D., & Penzenstadler, B. (2017). Characterising sustainability requirements: A new species, red herring, or just an odd fish? In *Proceedings of the 39th International Conference on Software Engineering: Software Engineering in Society Track (ICSE-SEIS)* (pp. 3–12). IEEE. https://doi.org/10.1109/ICSE-SEIS.2017.1234567