Incorporating Animals as Stakeholders in ICT: Towards Truly Inclusive Digital Sustainability

Roberto Vergallo[1][a] and Luca Mainetti[2][b]

[1]*Department of Information Sciences and Technologies, Pegaso Digital University, Piazza Trieste e Trento 48, Napoli, Italy*

[2]*Department of Innovation Engineering, University of Salento, via per Monteroni 165, Lecce, Italy*

Keywords: Sustainability, Digital Ethics, Wildlife, Biodiversity, Vegan Software, Animal Rights.

Abstract: The digital revolution has driven unprecedented technological advancements, transforming modern life and addressing global challenges. However, while sustainability efforts in Information and Communication Technology (ICT) are addressing environmental issues like energy consumption and carbon footprints, the ethical implications for non-human animals remain largely unexplored. This position paper calls for a redefinition of sustainability in ICT to include animal welfare as a core principle. We argue that animals should be recognized not only as indirect stakeholders impacted by technological progress but as direct beneficiaries of ethical digital practices. For the first time, we propose the concept of vegan digital product, also introducing an interdisciplinary methodological framework that prioritize animal welfare in digital design and policy-making. Particularly, the framework incorporates animal welfare as a scope-based non-functional requirement in ICT projects, including a draft for quantitative metrics based on the Value of Statistical Life (VSL).

1 INTRODUCTION

The digital revolution has transformed every aspect of modern life, driving innovation and creating unprecedented opportunities. However, its impacts on non-human animals remain largely unexamined. While sustainable software engineering has significantly adapted to minimize environmental impacts like energy and carbon footprints, yet the broader ethical impacts on animal life are frequently overlooked. The deployment of large-scale digital infrastructures potentially compromises animal habitats through land use for data centers, pollution from extracting and disposing of rare minerals, and disturbances from electromagnetic fields and digital devices. Additionally, technologies meant to enhance productivity, such as in smart farming, perpetuate exploitation by treating animals merely as resources rather than sentient entities deserving of ethical consideration.

At a time when public awareness and empathy for animal suffering are on the rise – as in the food, fashion, and entertainment industries – the lack of focus on animal welfare within the domain of ICT is both striking and concerning. There is the urgent need to broaden the concept of sustainability in the digital domain to include compassion and fairness towards all sentient beings. This includes developing ethical frameworks that integrate animal welfare into digital design and deployment, exploring the impact of digital infrastructures on animal habitats, and showcasing case studies of animal-friendly ICT applications.

This position paper seeks to address these gaps by advocating for a redefinition of sustainability frameworks to incorporate animal welfare as a core principle in digital and technological development. Specifically, it calls for the recognition of animals not merely as indirect stakeholders affected by technological progress but as direct beneficiaries who deserve thoughtful consideration and ethical respect. Central to this vision is the concept of "vegan digital product," an innovative approach that align digital innovation with the principles of non-violence and animal welfare. The objective is to foster an interdisciplinary discourse that bridges technological advancements with ethical imperatives.

To help digital companies report their efforts in mitigating animal suffering, in this paper we propose using the Value of Statistical Life (VSL) metric to quantify the life value of sentient animals affected by ICT products. Additionally, we draw inspiration from established frameworks, such as the Software Carbon

[a] https://orcid.org/0000-0003-3560-806X

[b] https://orcid.org/0000-0001-9387-9277

Vergallo, R. and Mainetti, L.
Incorporating Animals as Stakeholders in ICT: Towards Truly Inclusive Digital Sustainability.
DOI: 10.5220/0013431100003953

In *Proceedings of the 14th International Conference on Smart Cities and Green ICT Systems (SMARTGREENS 2025)*, pages 147-154
ISBN: 978-989-758-751-1; ISSN: 2184-4968

Intensity (SCI) specification and the Greenhouse Gas (GHG) Protocol, to introduce a novel methodological framework structured around a scope-based division.

The rest of the paper is structured as follows. Section 2 reports a multidisciplinary review on the relevant literature. Section 3 includes our position statement. Section 4 summarizes our contribution and sketches future research directions.

2 RELEVANT LITERATUE

The lack of consideration for the dignity and welfare of sentient animals is evident both in global agendas and in the digital sector. For instance, the United Nations Sustainable Development Goals (SDGs) prioritize reducing inequalities, but only among humans. Animals are mentioned briefly in Goal 2.5, and even then, only in a utilitarian context: to limit the risk of extinction for species deemed vital to human survival. Biodiversity appears to be the sole objective humanity assigns itself when discussing animal protection. ICT-related frameworks, such as the *IEEE Recommended Practice for Assessing the Impact of Autonomous and Intelligent Systems on Human Well-Being* (Committee, 2020), address biodiversity in terms of endangered species, protected habitats, and forest preservation. However, this perspective excludes farmed animals, which remain relegated to utilitarian roles under the same indicator (2.5) of the UN SDGs. Similarly, the Corporate Digital Responsibility (CDR) white (Shaw et al., 2024) paper defined as "a set of practices and behaviors that help an organization use data and digital technologies in ways that are perceived as socially, economically, and environmentally responsible," mentions biodiversity but avoids any reference to "animals" or "breeds". This reveals a glaring omission in addressing the dignity of non-human animals, both at a global level and within the digital sector.

The ethical neglect of animal welfare contrasts with philosophical insights and scientific evidence. (Hanna and Kazim, 2021) explores the Kantian theory of human dignity to argue that not all humans are "real persons," and that it is possible for animals, such as pets, to qualify as persons. This philosophical stance is further supported by scientific declarations. The 2012 *Cambridge Declaration on Consciousness* (Low et al., 2012) recognized that many non-human animals possess neurological substrates that generate consciousness, enabling them to experience emotions. The 2024 *New York Declaration on Animal Consciousness*[1] expanded this view, affirming that all vertebrates and many invertebrates likely possess consciousness. These findings emphasize the need to rethink human-animal relationships. Nevertheless, ethical treatment of animals should not hinge solely on their consciousness, as their dignity exists independently of their cognitive capacities.

The effects of digitalization on animals are significant, both in terms of their objectification and neglect in the face of technological side effects. For example, digital farming has raised serious ethical concerns. Neethirajan's work (Neethirajan, 2021; Neethirajan, 2023) explores the objectification of animals in modern farming systems, where the farmer's role shifts from caretaker to supervisor, emphasizing efficiency through real-time monitoring and predictive analytics. This shift, while technologically advanced, reduces direct human-animal relationships and raises questions about animal welfare. Neethirajan advocates for integrating ethical frameworks like Responsible Research and Innovation (RRI) (Burget et al., 2017) to ensure digital livestock farming technologies align with societal values, prioritizing the well-being of animals alongside sustainability.

Urbanization, often viewed as a driver of smart cities and digital advancements, also has indirect effects on animal welfare. Studies have long shown that urbanization reduces natural capital and biodiversity, as noted in (De Montis et al., 2021). McKinney (McKinney, 2008) reviewed over 100 studies on urbanization's effects, finding that species richness decreases with increasing urbanization, particularly in highly urbanized areas. The aggregate global impacts of urban expansion are expected to require significant policy changes to mitigate biodiversity loss (Seto et al., 2012). While sustainable city development emphasizes environmental aspects, animal welfare is notably absent from its objectives (Rabelo et al., 2017).

Another controversial aspect of digitalization is the widespread use of biologging devices, such as GPS and satellite trackers, to study animal behavior. While these tools have advanced ecological research (Hussey et al., 2015; Kays et al., 2015), they often impose physical burdens on animals, leading to behavioral changes or reduced survival rates (Duda et al., 2018). Research tends to focus on technological improvements, like energy efficiency of devices (Stroia et al., 2020), rather than addressing their impact on animal well-being. Similarly, electromagnetic radiation from mobile phone towers and devices has been linked to adverse effects on animal health, behavior, and reproduction. Studies have documented population declines in bats and other species near phone masts (Gauthreaux Jr, 1985; Balmori, 2009).

The controversial impacts of digitalization on an-

[1] https://sites.google.com/nyu.edu/nydeclaration/

imal welfare extend to other applications, such as drones disrupting wildlife (Rebolo-Ifrán et al., 2019; Wallace et al., 2018), land usage of data centers (Kshetri and Voas, 2024; Judge, 2021), mobile apps facilitating the consumption of animal-derived products (Lohmann et al., 2024), and the environmental toll of increased energy demands to power algorithms and digital systems (Belkhir and Elmeligi, 2018; Vergallo and Mainetti, 2024; Vergallo et al., 2024a; Vergallo et al., 2024b). This body of research underscores the critical gaps in global and digital policies regarding animal welfare. By failing to integrate compassion and dignity into the framework of sustainability, current approaches neglect the moral and ethical considerations necessary to ensure the well-being of all sentient beings.

3 POSITION STATEMENT

This paper advocates for embedding vegan principles into the design and development of software systems and ICT products in general. By particularly aligning software development practices with the core principles of vegan philosophy, this approach promotes a shift towards ethical, inclusive, and compassionate technology development, both in the ends and in the means. The adoption of these principles calls for a fundamental rethinking of how we define and measure digital sustainability, emphasizing metrics that account for the welfare of non-human animals.

Through a comprehensive framework that includes the integration of vegan philosophy into ICT design, the establishment of a precise definition of veganism for the digital realm, and the proposal of actionable metrics to evaluate animal-friendly practices, this position aims to redefine ethical digital technology. By doing so, it not only challenges prevailing paradigms of sustainability in ICT projects but also aligns software development with other industries.

In the following sections, this position is articulated in detail, starting with the philosophical underpinnings of incorporating vegan principles into digital products, including a formal definition of vegan ICT system and concluding with proposed metrics for assessing alignment with this vision.

3.1 Integrating Digital Technologies in the Vegan Philosophy

The Vegan Society, established in 1944, defines veganism as "a philosophy and way of living which seeks to exclude – as far as is possible and practicable – all forms of exploitation of, and cruelty to, animals for food, clothing or any other purpose; [...]"[2]. This definition highlights that veganism extends far beyond dietary choices, encompassing a broader commitment to eliminating animal exploitation in all forms, including production processes. It is clear, therefore, that reducing veganism to a dietary pattern is overly simplistic. The philosophy fundamentally opposes the exploitation of animals in every context, whether in large-scale industrial systems or small, localized practices, reflecting the principle that every life matters equally.

Despite this unified foundation, the vegan movement remains diverse in its motivations. Individuals adopt veganism for different reasons, often grouped into three primary categories: ethical concerns, environmental sustainability, and personal health. While substantial literature already supports the positive impacts of veganism on both the environment (Scarborough et al., 2023)(González-García et al., 2018)(Aleksandrowicz et al., 2016)(Ruini et al., 2015) and human health (Selinger et al., 2023)(Satija and Hu, 2018)(Pistollato and Battino, 2014), the concept of vegan digital product proposed here is rooted in the anti-speciesist dimension of the philosophy.

Our position grounds digital products development in ethical vegan principles, in order to advocate for a paradigm where the creation, deployment, and operation of digital technologies actively reject practices that harm non-human animals. This approach aligns with the broader philosophical framework of veganism, seeking to ensure that technology development reflects compassion and fairness towards all sentient beings. Similar to other non-food industries, such as textiles (Lamarche-Beauchesne, 2023) and medicine (Rodger, 2022), which have already established definitions of vegan products or adopted vegan practices in their production processes, we propose a corresponding definition for the ICT industry:

A vegan digital product, technology, or software is one that incorporates – as far as is possible and practicable – fairness toward non-human animals as a core non-functional requirement, applying this principle not only to the final aims and applications but also to every stage of its lifecycle, including design, development, testing, deployment, and maintenance.

To help identify direct and indirect causes of unfairness toward animals in digital systems, enhance transparency, and provide utility for various types of ICT organizations, ethical policies, and business

[2]https://www.vegansociety.com/go-vegan/definition-veganism

goals, we adopt an approach inspired by existing initiatives such as the Greenhouse Gas (GHG) Protocol[3] and ISO 14064 standard[4]. Specifically, we introduce three scopes of reporting:

- **Scope 1: Direct Discrimination.** This occurs when an organization provides ICT systems specifically designed to control non-human animals with the sole objective of improving the exploitation outcomes of both farmed and wild animals to meet human needs such as food, clothing, cosmetics, and healthcare. Examples include smart farming technologies, biologging devices, and software applications that perpetuate discrimination against animals.
- **Scope 2: Indirect Disturbance.** This accounts for the environmental modifications caused by digital systems merely by their operation or existence, while neglecting their impact on wildlife. For instance, the energy consumption of ICT technologies pollutes the air due to fossil fuel combustion, harming the habitats where animals live. Other examples include land use changes for building data centers and communication networks, or to mine rare earths needed for hardware parts, electromagnetic pollution from communication infrastructure, and drones disrupting or confusing natural migration processes.
- **Scope 3: Other Indirect Sources of Discrimination.** These arise from activities of the company but originate from sources not owned or directly controlled by it. Examples include Cloud services, the embodied impact of hardware and other digital procurement activities.

Figure 1 illustrates the integration of the three scopes into the phases of an iterative Software Development Life Cycle (SDLC). This model, chosen as an example, provides a framework for understanding how the potential impacts on non-human animals manifest across different stages of software development. The iterative SDLC consists of six phases: planning, requirements, analysis & design, implementation, testing, and evaluation, with a recurring feedback loop that includes operations and maintenance (incorporating deployment). Each phase plays a distinct role in shaping the lifecycle of a software product.

Scope 1 is most relevant in the requirements and analysis & design phases, as well as during evaluation. The requirements phase, where system objectives are defined, is particularly susceptible to incorporating specist thinking. During this phase, decisions can establish goals or specifications that directly target or marginalize non-human animals. Similarly, the analysis & design phase solidifies these requirements into concrete plans and system architectures, embedding any discriminatory assumptions into the foundation of the system. In the evaluation phase, the focus on assessing whether the system meets its goals often perpetuates these same specist frameworks, further reinforcing direct discrimination. Scope 2 aligns with the implementation and operations & maintenance phases. In these stages, the long-term environmental and ecological effects of digital systems are most apparent. The implementation phase involves the creation of software and hardware, often consuming significant energy and resources, contributing to environmental changes that may disrupt wildlife. Operations & maintenance, which includes deployment, extends these effects into the product's lifecycle, as its ongoing operation and maintenance require continued resource consumption, infrastructure support, and potential ecological disturbances. Scope 3 is tied to the value chain, explicitly addressing both upstream and downstream impacts. In the planning phase, upstream effects occur through material acquisition and preprocessing, where dependencies on supply chains or third-party technologies can inadvertently harm non-human animals. Downstream impacts become evident during the operations & maintenance phase, as the use of external services like cloud providers or digital procurement contributes to additional indirect harm.

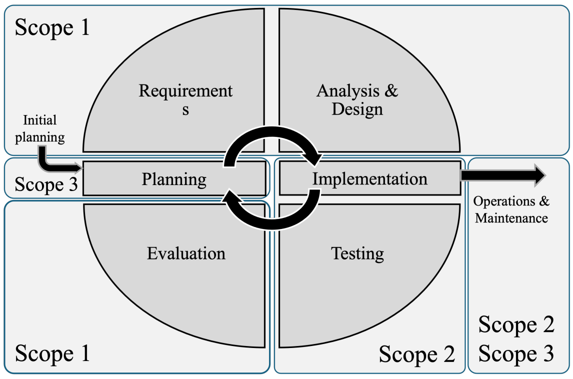

Figure 1: Mapping between Iterative SDLC phases and scopes of animal exploitation in IT projects.

3.2 Quantitative Reporting

The aim of this section is to propose a quantitative methodology for reporting the extent of animal exploitation or neglect in IT projects. Such reporting can serve multiple purposes: documenting the impact

[3]https://ghgprotocol.org/

[4]https://www.iso.org/standard/66453.html

of technology on animals to customers or buyers, assessing the effectiveness of mitigation strategies, driving decision-making processes, and showcasing commitment to addressing these concerns.

Quantitatively measuring levels of animal suffering is usually a matter of veterinary (Morton, 2023) and behavioral neuroscience (Singer, 1990) research, often with regards to experimental animals (Honess and Wolfensohn, 2010). In this position paper we suggest to adopt and adapt an existing metric from the economic sector which is the Value of Statistical Life (VSL) (Schelling, 1968)(Hirshleifer, 1970)(Viscusi, 1993)(Viscusi, 2019). VSL is an economic measure used to quantify the monetary value individuals place on reducing the risk of mortality. It is not the value of an individual life but rather the aggregate willingness to pay (WTP) of a population to reduce the risk of one statistical death. VSL is widely applied in cost-benefit analyses to evaluate public policies in areas such as health, environmental protection, and workplace safety, and it has been widely adopted to evaluate the impact of lockdown and other measures during the Covid-19 pandemic. The methodology typically derives its estimates from observed market behavior (e.g., wage-risk trade-offs in labor markets) or stated preferences in hypothetical scenarios. In many studies the value also includes the quality of life and the expected life time remaining. VSL can vary between regions (Liu et al., 2022). For instance, in the United States, recent estimates suggest a value of approximately 7.2 million USD. In Europe, VSL values differ by country, with Switzerland showing a value of about 9.4 million USD, while the median international value is around 1.3 million USD.

As an additional motivation for using VSL, we highlight that this metric is already employed by industry leaders in the field of sustainability. For instance, the marginal operating emissions provider WattTime utilizes it in their "health damage" data signal, expressed in VSL/MWh [5]. This signal estimates the harm to human health caused by emissions from electricity generation, based on the electricity consumed at a specific time and location. As a mere example, the health signal for the US ranged in $10-60$ \$/MWh during 2021[6].

To provide greater precision, we propose distinguishing between the Value of Statistical Human Animal Life ($VSHAL$, where $VSL = VSHAL$) and the Value of Statistical Non-human Animal Life ($VSNAL$). In alignment with the ethical principles underlying this work, we posit that the value of a human life is equal to the value of any other animal life, weighted by an optional index of sentience to each animal species, i.e.:

$$VSNAL = \alpha \cdot VSHAL \qquad (1)$$

The index of sentience (α) should be set to 1 for non-human animals with cognitive and sensory capacities qualitatively comparable to those of humans (e.g., mammals, birds, cephalopods). However, other animals, such as those lacking a central nervous system or a brain, while still deserving of ethical consideration, may have a lower capacity for experiencing physical and emotional suffering. The assumption in Eq. 1 does not strictly follow the technical definition of VSL, which is inherently anthropocentric and grounded in economic evaluations. Instead, it reflects a philosophical stance that all sentient beings hold intrinsic and equal value, providing an ethical foundation for the measurements proposed in this work. Moreover, we acknowledge that some interpretations may argue for $VSHAL$ to exceed $VSNAL$, citing factors such as differences in life expectancy or body size. For readers who find it challenging to adopt the equality presented in Eq. 1, the equation could alternatively be applied as an upper-bound estimate. This approach would still align with the core objectives outlined at the beginning of this subsection while accommodating varying perspectives. Moreover, we remind that VSL already varies among human animals born in different countries, still being considered a valid indicator.

Defining N_1 as the number of animals impacted by activities in Scope 1, then it follows that the non-human animal life damage D for Scope 1, in monetary unit (e.g. USD), is:

$$D_{\text{Scope1}} = N_1 \cdot VSNAL \quad [\text{USD}] \qquad (2)$$

This term is designed to weigh heavily in the final computation, as it carries the cost of all beings whose discrimination is supported by the digital system. Moreover, given the turnover of animals in the locations where the system is applied, this metric is bound to grow proportionally over time.

Damage for Scope 2 involves all the indirect effects on an estimated number of animals N_2 whose habitats are modified due to digital activities. This impact can be decomposed into five key dimensions: air, water, soil and habitat loss, plus radiation effects:

- A (air): The air breathed by N_{1_A} animals gets polluted by GHG derived from energy production needed to run the digital system. The damage is quantified using the health signal ($VSNAL/MWh$), reflecting the indirect harm caused by reduced air quality.

[5]https://watttime.org/data-science/data-signals/health-damage/

[6]Source: own elaboration of data obtained from a special agreement with WattTime.

- W (water): The availability and quality of water, essential for the survival of N_{2_W} animals, are altered due to the water consumption and contamination associated with ICT operations. For example, cooling processes in data centers may deplete local water sources or discharge heated or polluted water into ecosystems. The damage is calculated by assessing the deviation from baseline water needs (W_{baseline}) and the cost in terms of VSNAL for affected animals.
- S (soil): The quality and availability of soil that N_{2_S} animals depend on are impacted. This includes contamination from improper disposal of electronic waste, and land degradation. The damage is calculated by evaluating the area of soil affected (S_{area}) and the resulting harm to the dependent animal population (VSNAL).
- H (habitat): The construction of data centers, communication networks, and other ICT infrastructure such as drones and satellite ground stations directly impacts the living conditions of N_{2_H} animals. This includes the deforestation or conversion of natural landscapes into industrial zones, leading to displacement, reduced access to resources, and increased vulnerability to predators or environmental changes. The damage is calculated by assessing the total area of habitat lost (H_{area}) and the number of displaced or affected animals, weighted by their dependency on the specific habitat type. The impact is then expressed in terms of VSNAL per affected population.
- R (radiation): Electromagnetic interference from ICT assets, such as cell towers, communication networks, and drones, affects wildlife. For example, migratory species and animals that rely on natural electromagnetic fields for navigation (N_{2_R}) can experience disorientation, stress, or disrupted life cycles. The damage is quantified based on the affected species and populations, with measurement units reflecting electromagnetic exposure levels (e.g., μT) and the corresponding impact on animal welfare (VSNAL).

The summation of the aforementioned contributions gives the health damage for Scope 2:

$$\begin{aligned} D_{\text{Scope2}} &= D_A + D_W + D_S + D_H + D_R \quad \text{[USD]} \\ &= (N_{2_A} \cdot VSNAL) \\ &+ (N_{2_W} \cdot VSNAL \cdot \Delta W_{\text{used}}) \\ &+ (N_{2_S} \cdot VSNAL \cdot S_{\text{area}}) \\ &+ (N_{2_H} \cdot VSNAL \cdot H_{\text{area}}) \\ &+ \left(N_{2_R} \cdot VSNAL \cdot R_{\text{intensity}}\right) \end{aligned} \tag{3}$$

Exploding the different terms in Eq. 3 is presented here in a conceptual manner. The formal mathematical structure, along with the methodology for collecting the necessary data to feed the formula, require further refinement and validation and represent a work in progress. Moreover, the equation assumes that the components D_A, D_W, D_S, D_H, and D_R are independent. While this simplifies the calculation and makes the model more practical, it overlooks potential correlations between these components. As a result, the current model should be understood as providing an upper bound for Scope 2. This approach ensures that no potential impact is underestimated but calls for refinement in future iterations to incorporate interdependencies more accurately.

Finally, the total damage falling in Scope 3 is simply the summation of the VSNAL for each external resource r acquired by the company:

$$D_{\text{Scope3}} = \sum_{r \in R} \text{VSNAL}_r \quad \text{[USD]} \tag{4}$$

Here, R denotes the set of external resources acquired by the company to sustain its digital activities (both tangible and intangible assets). Each resource $r \in R$ represents an individual component within this set, such as hardware (e.g., servers, networking equipment), software services (e.g., Cloud computing or third-party applications), and supply chain contributions (e.g., energy procurement, subcontracted services). The VSNAL_r term quantifies the impact of each resource r on non-human animals, considering the resource's lifecycle from material extraction and production to delivery and eventual usage.

It trivially follows that the total damage D is the summation of the contributions of each scope:

$$D = D_{\text{Scope1}} + D_{\text{Scope2}} + D_{\text{Scope3}} \quad \text{[USD]} \tag{5}$$

Inspired by the Software Carbon Intensity (SCI) metric proposed by the Green Software Foundation[7], we define the Damage Intensity (DI) as the total damage D normalized by a functional unit R:

$$DI = D \,\text{per}\, R \quad \text{[USD/unit]} \tag{6}$$

The functional unit R provides a versatile mean to evaluate how the damage scales across different dimensions, making it possible to tailor the metric to the specific context of its application. For instance, R could represent a temporal scale (D/year), a per-product basis, per customer, or more technical metrics like per API call. In this way, organizations can align the metric with their reporting frameworks.

As a final consideration for this section, while Scopes 2 and 3 present significant challenges in both measurement and mitigation, we strongly advocate

[7] https://sci.greensoftware.foundation/

for the immediate and actionable step of fully eliminating costs associated with Scope 1.

4 CONCLUSIONS

In this position paper, we have introduced a new dimension of sustainability for ICT including animals as stakeholders throughout all phases of the lifecycle of digital artifacts, encompassing both software and hardware. This perspective is grounded in the recognition of the sentience of non-human animals, which are often objectified or neglected in modern digitalization processes. Furthermore, the ICT sector lags behind other industries such as food, fashion, and entertainment, which have already adopted innovative market propositions aligned with animal welfare principles. This work calls for a concerted interdisciplinary effort to establish a dialogue that addresses the need for anti-speciesist technology. The key contributions of this paper are summarized as follows:

1. **Multidisciplinary State-of-the-Art.** We have curated and synthesized insights from key studies across ethics, biology, energy, and computer science, fostering a comprehensive and interdisciplinary foundation to promote dialogue among researchers from diverse fields.
2. **Definition of Vegan IT.** For the first time, to the best of our knowledge, we have positioned the digital sector within the broader vegan philosophy, proposing a clear definition of what constitutes a vegan digital product.
3. **Framework Proposition.** While still in its preliminary stages, we have introduced a methodological framework that incorporates animal welfare as a non-functional requirement in ICT projects. This framework includes a division into scopes and a draft for quantitative metrics, enabling ICT companies to assess and demonstrate their commitment to animal welfare.

While this paper primarily serves as a position piece to introduce speculative ideas, it currently lacks an application of the proposed framework. As a result, the mathematical foundation remains at a conceptual stage and requires further refinement to become actionable and suitable for industrial adoption. Future work will focus on presenting numerical results to illustrate how a reference scenario could be improved by adopting our method, thereby demonstrating its practical impact.

The impact of digital technologies on animal welfare is unavoidable. However, minimizing this impact to the greatest extent possible is both feasible and ethically imperative. Establishing a clear standard for reporting the impact of digital products on non-human animals paves the way for certifications in vegan IT, empowering customers to make informed choices.

ACKNOWLEDGEMENTS

We thank WattTime for providing the health data.

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