

SPECIAL TOPIC

*Practices and concepts
of care in sustainability
transformations:
Critical perspectives in
technology assessment*

*Care-Praktiken und -Konzepte in Nachhaltigkeitstransformationen:
Kritische Perspektiven in der Technikfolgenabschätzung*

Edited by S. Hackfort, J.-L. Reinermann
and D. Gottschlich



INTRODUCTION

Critical perspectives in technology assessment: On the relevance of care for sustainability transformations

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Abstract • In the introduction to the Special topic, we highlight the importance of exploring concepts, approaches, and practices of care in order to give new impetus to technology assessment and to unlock the potential of such approaches for a socio-ecological transformation toward critical-emancipatory sustainability. The introduction also contains a brief description of each article.

Kritische Perspektiven in der Technikfolgenabschätzung: Zur Bedeutung von ‚Care‘ für Nachhaltigkeitstransformationen

Zusammenfassung • In der Einleitung zum Special topic zeigen wir, wie wichtig die Auseinandersetzung mit Care-Konzepten, -Ansätzen und -Praktiken ist, um der Technikfolgenabschätzung neue Impulse zu geben und das Potenzial solcher Ansätze für eine sozial-ökologische Transformation in Richtung kritisch-emanzipatorischer Nachhaltigkeit zu erschließen. Die Einleitung enthält außerdem eine kurze Beschreibung der einzelnen Artikel.

Keywords • care, socio-ecological transformations, sustainability, technology

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Objectives

We aim to showcase new research and experience related to care concepts, approaches, and practices that foster sustainability transformation in this Special topic of TATuP, thereby offering fresh perspectives for technology assessment (TA). Our intention is to discuss the empirical value of care in critically assessing the role of technologies and to explore its importance for the empirical analysis of technological innovations in sustainability transformations. Practical applications of care are therefore discussed in this context and examined with respect to how it can enrich current debates in TA. Our interest is to explore how the concept of care can extend beyond and enhance current debates and frameworks such as the precautionary principle. We address ways in which concepts of care can be used to inform technology policies, governance processes, and regulation related to digitalization, artificial intelligence, and other new and emerging technologies. In addition, its strengths and weaknesses, limits and opportunities are identified. This topic essentially explores how care can contribute to, and be enriched by, new perspectives to ultimately foster a more sustainable economy.

In this context, we focus on political initiatives for sustainability transformations, such as the green economy, the bioeconomy, and the circular economy. These initiatives have all been criticized for being too focused on economic growth and technological solutions (Gottschlich et al. 2014; Boyer et al. 2023; Eversberg et al. 2023; Geiter et al. 2025). However, despite the justified criticism of pure techno-fixes, some technologies do have the potential to advance transformation towards more sustainability. For example, urban transformation can benefit from

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intelligent infrastructures to effectively coordinate various inter-sectoral transformation processes such as renewable mobility, electricity and heat generation.

Hence, this Special topic examines selected technologies that shape our society, while presenting a critique of technological solutionism. As the risks and impacts of existing and emerging technologies on society and nature are often uncertain, unknown, or controversial, their assessment with a focus on precaution and care becomes essential.

isting work on the concept of care and technology policy highlights its potential to draw attention to issues often neglected in innovation theory or risk assessment, such as responsibility, relationality, contextuality, dependency, or power relations. This focus also brings attention to institutions that regulate and govern social or technological innovations, political processes, and economic practices (Groves 2015; Martin et al. 2015; Hackfort and Saave 2024). Scholars in this field have identified key features of a care perspective on technologies, particularly in assessing

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To some extent, this has already been done in participatory TA, where expert assessments (Sauter 2005; Albrecht et al. 2017; Stirling et al. 2018; Reineremann et al. 2022), responsible research and innovation (Asveld et al. 2015; Felt 2018), and other risk assessment approaches in key sectors like energy, planning and infrastructure, or food and agriculture have already incorporated elements of it to varying degrees (Levin-Keitel et al. 2018; BfR 2019; Thompson 2020; CSPO 2021; Participedia 2024).

However, it has been argued that many of these approaches still operate within flawed and overly narrow technology and risk assessment frameworks that inadequately consider the complex societal and political contexts and their inherent uncertainties (Groves 2015; Garnett 2021; Whittingham and Wynberg 2021).

In order to more fully critically engage with conceptualizations and practices of care in TA of sustainability transformations, we have gathered contributions from different disciplines and research perspectives ranging from political science, sociology, political agroecology, environmental and agricultural engineering, innovation studies, science and technology studies.

As the state of research on this topic in German TA debates is rather limited and the reception of debates around concepts of care in this field has just started, we aim to broaden the international visibility of care approaches and further advance the debate in this field with this journal's Special topic.

State of research

Care approaches relevant to our topic have evolved in various debates and across disciplines. A care perspective, as developed in (feminist) science and technology studies, offers important insights for critically assessing innovations aimed at sustainability. The question which technological innovations advance socio-ecological transformations is of crucial importance. Ex-

the risks and implications of biotechnology and genetic engineering (Preston and Wickson 2016; Puig de la Bellacasa 2011; Whittingham and Wynberg 2021). One example of this is the increasing control over food production and the marginalization of agroecological approaches as a consequence of genetic engineering in the agricultural industry (Curry 2002; Preston and Wickson 2016; Whittingham and Wynberg 2021).

Concepts of care advocate for including socio-economic, cultural, and political factors in risk assessment, such as the influence of economic interests of various actors and power dynamics. A care perspective involves a concept of risk that differs from a “consequentialist-based framework of assessment” (Whittingham and Wynberg 2021, p. 2) for technologies. While the latter is based on a positivist understanding of (natural) science with claims to objectivity and derives risks from technologies accordingly (proven negative effects of genetic engineering on human health or the environment), a care perspective criticizes this as too narrow. Feminist critiques of science have shown that the claim to objectivity is itself problematic, as every theory, experiment, and innovation is already based on human-made assumptions and ideas. Proponents emphasize that every discipline of knowledge production, including the natural sciences, is embedded in society and that scientific findings are therefore always influenced by social power structures. The category of gender plays a particularly important role here, as even the seemingly neutral perspective of natural scientists is often shaped by unconscious societal notions of gender and gender relations (Harding 1991).

Donna Haraway's concept of ‘situated knowledge’ (Haraway 1991), for instance, emphasizes that knowledge is always partial and situational and that assumptions must be made transparent. This requires negotiating different perspectives and including diverse actors. Doing so helps to avoid the exclusion of knowledge forms and thus achieve something akin to objectivity. Recent work using care as a lens to assess technologies aligns with this feminist critique of science. It highlights the legitimacy of

diverse forms of knowledge and challenges the existence of patriarchal, technocratic power structures in knowledge production and in political and decision-making spaces in innovation policy. The work advocates for a more democratic and inclusive process instead that reflects the diversity of voices, especially those of marginalized groups — “the multiplicity of scientific and academic voices but also the voices of the marginalized” (Whittingham and Wynberg 2021, p. 3). Further important approaches in this emerging field therefore include decolonial or degrowth perspectives to critique the “objectification of nature” (Arora and Van Dyck 2021, p. 254) traditionally upheld in Western modernity and the solutions arising from its paradigms (Puig de la Bellacasa 2011; McGreevy et al. 2022).

Another strand inspired by feminist democracy theory, which we find stimulating to explore, is the importance of care in the empirical analysis of technological innovations in sustainability transformations. This includes literature on care as a transformative principle for society, politics and the governance of society-nature relations (Fisher and Tronto 1990; Tronto 1993; Gottschlich et al. 2014; Gottschlich and Katz 2020). Particularly in the field of political ecology, the term refers to care work for future generations, for nature, for animals and plants, as well as their respective specificities and characteristics. It fundamentally embodies a critique of economic relationships that prioritize logics of growth and exploitation over social and ecological reproduction needs and the fulfillment of basic necessities. Concepts of care are aimed at a greater awareness of our relationship with nature. They thus provide ethical tools for a precautionary economic and life-sustaining technology policy to meet the challenges of justice and sustainability while going beyond existing debates and concepts on the precautionary principle (Gottschlich and Bellina 2017; Gottschlich and Katz 2020; Gottschlich and Hackfort 2022).

For example, a precautionary care approach to farming and food production considers, among other things, nature’s own time, aims to preserve and improve soil fertility (Puig de la Bellacasa 2011), combines ecological and social justice issues, and applies the principle of care and precaution when assessing the use of new technologies such as genetic engineering or precision agriculture (Whittingham and Wynberg 2021; Hackfort and Saave 2024). Care-centered critical-emancipatory approaches direct attention to the socio-ecological transformation processes that must align with the political institutions, and production processes and lifestyles in industrial capitalism (Wichterich 2021). Such transformations can only succeed if social inequalities are addressed and overcome. Critical-emancipatory approaches to sustainability that places the concept of care at the core allow us to take into account these social dynamics (Gottschlich 2017; Gottschlich and Katz 2020; Anderson 2021). Here scholars refer to care in a broad sense “as a species activity that includes everything that we do to maintain, continue, and repair our ‘world’ so that we [and other earth others] can live in it as well as possible” (Fisher and Tronto 1990, p. 40, cit. in Tronto 1993, p. 103).

Contributions to this Special topic

The contributions in this Special topic explore concepts and practices of care that highlight and enable alternative imaginaries and politics of technologies and practices of TA in sustainability transformations. Taken together they need to be understood as an approximation, as a kind of test field in which the relationship between society, nature, and technology from different care perspectives are investigated using different questions and varying approaches to diverse themes.

The article ‘Decolonizing technology assessment: Towards a radical transformation of the modern world’ by Saurabh Arora and Barbara Van Dyck offers a conceptual approach to decolonizing TA in relation to agriculture. The authors highlight the persistence of colonial relations not just between nations, but critically between socio-material worlds that support different ways of being and knowing in agriculture and across agroecologies. The authors move beyond colonial relations of superiority and supremacy, control and domination, extraction and appropriation, which inform the modern world. Saurabh Arora and Barbara Van Dyck put forward the notion of radical care, which draws from feminist and indigenous movements. They advocate for decolonizing TA which involves providing support and solidarity for struggles aimed at confronting and dismantling colonial relations that sustain the concentration of power and privilege in modern societies. They support their conceptual proposals with brief examples from agriculture. Doing so, they seek not only to address and challenge patterns of power and privilege related to technologies and innovations that tend to harm (colonized) communities, but also to promote alternative ways of knowing supported by colonized peoples, whose life-sustaining practices have shaped multiple worlds. This care approach goes beyond the colonial dynamics between nations and cultures, emphasizing contemporary interactions with diverse worlds both during and after colonial rule, and encompassing perspectives from both the Global South and North. Arora and Van Dyck’s article offers a widely overlooked approach by emphasizing a decolonial view of TA. With it they contribute to a better understanding of how TA can transcend precaution as techno-scientific pluralism and dismantle colonial relations both within and between societies.

Sarah Maria Schönbauer addresses in her article ‘Careful handling of marine plastic litter: Technology assessment and care’ waste as a core concern in today’s societies. Using the example of marine plastic litter, which has dire effects on ocean ecosystems, she discusses how TA scholars can address the issue and explores care concepts for TA processes concerning waste. In the article, she illustrates how care concepts not only help to understand the complexity of waste but also the environments they affects, the regulatory processes involved, and the technical innovations that arise. Sarah Maria Schönbauer argues that focusing on environmental care in care reflection processes could assist TA practitioners in sensitizing TA practices not only towards concerns on different scales of world politics but also to emotional attach-

ment, responsibility distribution and marginalization processes, core characteristics of care that open up “neglected experiences that create oppositional standpoints” (Puig de la Bellacasa 2011, p. 96).

Johanna Krings and Nora Weinberger in their contribution ‘Technology or practices of care first?: Technology assessment in the tension between ‘technology push’ and managing socio-technological futures’ underscore the crucial role of TA in balancing technological development with care principles. While TA has integrated care-based approaches, project outcomes reveal that these efforts are insufficient for fostering truly ‘caring’

Benedict Lang’s article is titled ‘Daseinsvorsorge’ as a care-based principle of transformation: Perspective toward a caring development of sustainable cities’. He addresses smart cities that use sensors, data and applications to transform urban infrastructures towards sustainability. Critical scholarly examinations of the smart city have failed to integrate care. Based on empirical insights, he argues that ‘öffentliche Daseinsvorsorge’ (understood as public services essential for ensuring a basic quality of life) presents a guiding principle of urban statecraft that initiates responsible research and innovation based on care reflections. He explores the concept as a critical lens for evaluating transfor-

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societies. Technological solutions often lack alignment with the specific needs of users and the social contexts of care, creating significant tensions. The article advocates for a ‘care-sensitive’ TA that not only ensures technological robustness and adaptability but also facilitates continuous ‘tinkering’ to refine technologies within dynamic care settings. A reciprocal, context-aware approach benefits both caregivers and recipients, embedding technology into care practices rather than subordinating care to technological imperatives. Ultimately, such an approach promotes a more responsive, empathetic caregiving environment where technology finds its ‘place’.

Corinna Peil’s article ‘Infrastructures of care: Ethics in everyday digital media use’ presents a novel conceptualization of digital media as infrastructures of care, integrating care ethics to examine the role of maintenance and support in fostering sustainable and equitable digital environments. By examining challenges and user support relations within digital media use, it proposes policies that enhance technological sustainability and inclusivity, emphasizing the role of care in ensuring the reliability and functionality of digital infrastructures shifting our focus towards their sustainable maintenance and usage. Peil underscores Krings and Weinberger’s position that a precautionary development of technology based on care can represent a continuous technological improvement of socio-ecological conditions through a reciprocal understanding of relationships with users. She argues that technological literacy is crucial, as we are surrounded by technological artefacts, especially in the Western world. These artefacts organize, structure, and also inform our societies as well as our everyday lives. For Peil, care becomes a political category, as there is a need for a policy of knowledge that focuses on the care and maintenance of technology.

mation projects from a care perspective. Lang demonstrates that the literature on responsible research and innovation overlooks a discussion of what precautionary technology development truly entails, as well as the values associated with it. In addition, he proposes a normative framework that reflects the role of municipal administrations and their responsibilities towards citizens. He then argues for a care-oriented concept of ‘öffentliche Daseinsvorsorge’ – essential public services that ensure a basic quality of life – to evaluate and assess sustainability transformations and their technological implications beyond existing debates.

To promote social-ecological transformation and a sustainable economy, Andrea Vetter pleads in her interview ‘How to care about technology?’ for instituting a ‘moral code for technology’ that is committed to the principle of care. Maintaining technical infrastructures and devices requires a lot of care, without which they would fall apart. To take on this care work, it is essential that people relate directly to technology and have the knowledge not only to use it but also maintain it.

Conclusion

The articles in this Special topic offer valuable insights into how incorporating a care perspective into technology assessment can facilitate social-ecological transformation. It is evident that, while care concepts are interpreted in various ways in practice, common elements in care approaches include a critique of power relations, the significance of relationships and an examination of who benefits from technology.

With all the contributions in this Special topic we hope to establish a care perspective on sustainable development that re-

search has insufficiently taken into consideration. A care perspective calls for the acknowledgement of uncertainty and complexity, and is based on the key principles of responsibility, relationality, contextuality, and dependency. It aims to broaden our understanding of technologies and their implications while widening our notion of (appropriate) solutions including non-technological or low-technology approaches to maintaining nature's reproductive capacity as key for sustainability. We firmly believe that any technological innovation, assessment, economic activity, or political governance that does not incorporate care as an intrinsic component will ultimately fail to achieve sustainable economies and societies.

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RESEARCH ARTICLE

Decolonizing technology assessment: Towards a radical transformation of the modern world

Saurabh Arora^{*1} , Barbara Van Dyck² 

Abstract • This research article makes a conceptual contribution to decolonizing technology assessment (TA) by highlighting the persistence of colonial relations, not only between nations but also between different ways of knowing and being. Beyond the modern, these ways are often categorized as Indigenous, traditional, vernacular, artisanal and local. Against many such ways, the modern world has enacted colonial relations of superiority and supremacy, control and domination, as well as extraction and appropriation. To help transform these globally extensive relations, we call to decolonize TA through radical care for the social-material bases of colonially marginalized ways of being and knowing. This means that TA should enable refusals of modern innovations if they are likely to damage those social-material bases. Furthermore, radical care in TA means practicing solidarity with decolonial movements that directly confront entrenched colonial relations behind modern concentrations of power and privilege. We support our arguments with brief examples from agriculture.

Entkolonialisierung der Technikfolgenabschätzung: Hin zu einer radikalen Umgestaltung der modernen Welt

Zusammenfassung • Dieser Forschungsartikel leistet einen konzeptionellen Beitrag zur Entkolonialisierung der Technikfolgenabschätzung (TA), indem er das Fortbestehen kolonialer Beziehungen nicht nur zwischen Nationen, sondern auch zwischen verschiedenen Wissens- und Existenzweisen hervorhebt. Über Kategorien der Moderne hinaus werden diese oftmals als indigen, traditionell, alltagsbezogen, handwerklich und lokal eingestuft. Vielfach hat die moderne Welt ihnen koloniale Beziehungen der Überlegenheit und Vorherrschaft, der Kontrolle und Beherrschung sowie der Ausbeutung und Aneignung auferlegt. Als Beitrag zur Transformation der globalen Beziehungen rufen wir dazu auf,

die TA durch radikale Fürsorge für die sozial-materiellen Grundlagen kolonial marginalisierter Wissens- und Existenzweisen zu dekolonisieren. Das bedeutet, dass TA die Ablehnung moderner Innovationen ermöglichen sollte, wenn sie diese sozial-materiellen Grundlagen schädigen könnten. Darüber hinaus bedeutet radikale Fürsorge in der TA Solidarität mit Entkolonialisierungsbewegungen zu üben, die sich gegen moderne Konzentration von Macht und Privilegien sowie dahinterstehende etablierte koloniale Beziehungen stellen. Wir unterstützen unsere Argumente mit kurzen Beispielen aus der Landwirtschaft.

Keywords • sustainable development, colonial modernity, radical care, pluriversal flourishing, agricultural sustainability

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Introduction

Technology assessment (TA) has been central in attempts to democratize modern techno-scientific developments (Grunwald 2019). Serving as a bulwark against technocracy, TA has mobilized a range of concepts and methods including participatory techniques, precautionary principle, responsibility (and anticipation) in innovation governance, care ethics, and even anti-colonialism. Despite these major achievements, however, TA approaches neglect that modern technosciences are developed within a world made by colonial relations over five centuries since the first genocides in the Americas (Quijano 2000; Gaonkar 2001). It is this modern world that is now globally hegemonic in its many forms and lies behind the development of industrial agriculture based on technologies such as genetically engineered crops and massive irrigation infrastructures (Arora and Van Dyck 2021). Conceptualizing this world as *colonial modernity* (Arora and Stirling 2023), we argue that TA must help confront and transform modern world-making so that colonially marginalized ways of being and knowing can once again thrive.

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Our times are deeply affected by social-ecological crises of many kinds including wars and biodiversity losses, as well as climate injustices and vast inequalities, which are linked to the widespread use and development of modern techno-sciences. While TA has made crucial contributions to governance of innovation for sustainability, many social-ecological crises have worsened in the last five decades. In this context, it is important for TA to move beyond governance of individual innovations and help pluralize directions in modern progress (Stirling 2008). More critically, TA must help confront historically entrenched patterns of social-material and political-ontological relations that

techno-sciences may be unknown and causal chains may be unpredictable (Wynne 1992). Where uncertainties are not reduced to risk, the precautionary principle (PP) may be foregrounded (Stirling 2014). PP mandates that technology governance must not wait for full scientific certainty, if there are *possibilities of undesirable health and environmental effects* (Harremoes et al. 2001). Precaution thus requires action for protection by regulating or postponing the use of an innovation. It is perhaps for this reason that PP is opposed by political and economic interests behind innovations, and labelled as ‘anti-science’ or ‘anti-innovation’ (Stirling 2014).

Addressing social justice and ecological integrity, care-based approaches usefully extend earlier work on uncertainties and precaution.

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make and receive modern techno-sciences (Quijano 2007; Arora et al. 2020). These underlying relations that constitute colonial modernity in its different forms, resist change even as they make all kinds of novel techno-sciences promoted as inevitable or sustainable (Arora and Stirling 2023). We discuss six such relations that are tangled up with each other in modern technological developments and call to re-imagine and re-enact TA concepts and methods for transforming colonial modernity.

These six relations are: assuming comprehensive superiority, extending imagined control, enforcing gendered domination, appropriating cultural privileges, asserting military supremacy and expanding toxic extraction (Arora and Stirling 2023). They exist not just between nations and racialized groups, but also *between different worlds* that underpin many ways of doing knowing (beyond colonial modernity’s sciences and technologies). We argue that decolonial TA foregrounds radical care for social-material bases of Indigenous and other colonially marginalized ways of knowing and being. This means that TA efforts must enable refusals of modern innovations where they are appraised as carrying possibilities of exploiting colonially marginalized worlds, no matter how uncertain or ambiguous such appraisals might be. Further, decolonizing TA means solidarity with social movements and struggles to dismantle colonial relations that underpin modern concentrations of power and privilege.

Assessing modern technology

Since the 1970s, TA approaches have developed valuable insights into the precautionary principle; participatory decision-making processes; and contested values in society to underscore responsible research and innovation (RRI).

Uncertainties inherent to techno-sciences can be reduced to probabilistic risk of well-defined possible occurrences (Callon et al. 2009). This reduction overlooks that futures afforded by new

Such labelling, however, neglects that precaution in TA aims to empower social choice. PP may mean the rejection of toxic innovations such as synthetic pyrethroids and neonicotinoids (Maderson 2023), but it also means the steering of innovation along many alternative possible pathways. Precaution therefore is about enabling techno-scientific pluralism (Stirling 2014).

Beyond precaution, to deal with uncertainties and mobilize robust evidence from diverse actors including the most marginalized, TA has embraced participation at all stages of innovation (e.g., constructive technology assessment: Schot and Rip 1997). Participatory TA is considered crucial for gaining greater legitimacy of governance decisions (Grunwald 2019). Participation can improve social learning and collaboration among ‘lay citizens’ and ‘expert practitioners’. However, in settings saturated with asymmetric power and privilege such as the promotion of ‘smart’ agricultural technologies among smallholders, participatory processes can be easily instrumentalized. For instance, some participants’ perspectives may be cherry-picked to suit entrenched interests. Thus, participation can be enacted to put “democracy at the service of technocracy.” (Ghosh and Arora 2022, p. 320)

Arguably to address such issues (van Lente et al. 2017), the last two decades have seen the rise of RRI (Stilgoe et al. 2013). Central here are ethical concerns about emerging technologies, including genome editing techniques like CRISPR/Cas9 and newer insecticides, herbicides, fungicides and nematicides for ‘crop protection’ (Maienfisch and Koerber 2024). However, using academic discourses of anticipation, reflexivity, inclusion and responsiveness (Stilgoe et al. 2013), RRI can inadvertently end up legitimizing highly controversial innovations through their ostensible embedding “in ethical principles accepted by society” (Gremmen 2023, p. 201). Thus, RRI can jeopardize hard-fought gains made for democratizing innovation through TA’s institutionalized precautionary and participatory processes (Delvenne 2017). Playing limited role in enabling social choice over diverse

possible directions of innovation, RRI also neglects how entrenched political formations of colonial modernity close down alternatives (Stirling 2024).

RRI and other TA debates have nevertheless engaged with the concept of modernity, particularly following Beck's (1992) argument of *reflexive modernization*. Due to its focus on governance of risks associated with industrialization, TA is seen by some proponents as directly attuned to reflexive modernization (Hennen 1999; Grunwald 2019). Modernity is also prominent in TA debates on globalization (Hennen et al. 2023). Approached mainly as the extension of the 'West' into 'developing' countries, globalizing modernity is seen as posing significant challenges to TA approaches focused on wealthy nation-states. In this context, the usefulness of a diversified 'global TA' is appreciated but seen as a distant reality (Grunwald 2019). Such engagements with modernity, however, neglect its colonial constitution.

Indigenous perspectives

Indigenous studies scholars highlight how colonialism is omitted from sustainability claims of modern technologies and from Eurocentric studies of their governance. For example, scrutinising settler-colonial genetic engineering of salmon in the USA, Schneider (2022) shows how modern TA overlooks Indigenous knowledges developed over thousands of years of observing and experiencing salmon. By ignoring historically accumulated knowledges and Indigenous ways of knowing, TA exercises may conclude that an industry is "safe" for wild salmon, while it is nothing of the sort. Contrasting forms of Indigenous TA not only take plural values seriously but also appraise how technologies can play a "restorative role in the continual rebalancing of the world" (Schneider 2022, p. 246).

Examining corn seeds in Hawaii's industrial food system that relies on privatisation of Indigenous lands and germplasms (and TA that neglects Indigenous alternatives based on care for

Extractive relations are underpinned by colonial fantasies of control.

Feminist perspectives

Feminist TA approaches go beyond "inclusion in existing unequal systems and structures of knowledge production", to question "the underlying discursive and material power relations that enable exclusion" (Hackfort and Saave 2024, p. 2). Feminist approaches foreground *politics of care* around modern techno-sciences (Martin et al. 2015), which includes deliberating gendered divisions of labour and resisting the externalisation of technologies' socio-ecological consequences (Hackfort et al. 2024). Addressing social justice and ecological integrity, care-based approaches usefully extend earlier work on uncertainties and precaution (Whittingham and Wynberg 2021).

Feminists caution against an "intentionally *feminized* ethic of care" (MacGregor 2004, p. 61, italics in original), which can essentialize women's subjectivities. Grounded instead in everyday practices and diverse relations, politics of care go beyond presumably stable identities and abstract conceptions of rights and justice (Martin et al. 2015). In particular, affect is articulated to center care in TA. Affect recognizes multiple rationalities and emotions – including gut reactions and moral doubts – in people's relations with technologies. Care also means attending to shifts or ruptures in relations afforded by new technologies (Wickson et al. 2017).

Examining biotechnology regulation in South Africa, Whittingham and Wynberg (2021, p. 8) note that care can help reimagine and redesign relationships to move beyond "values of a patriarchal-technological culture that stems from colonial and developmental ideologies of yield, productivity and efficiency". Care-based approaches to TA thus need to be situated against the wider (post)colonial context of modernisation (Arora et al. 2020).

the land and on connections between communities' and lands' health), Gupta (2015) frames activism against genetically modified corn as part of the Kanako Maoli' struggles to foreground *Aloha 'Āina* or love for the land. Similarly, Maori scholar Baker (2012) calls for collectivist views in assessments to undo hierarchies between 'experts' and 'lay' people, supporting calls for TA frameworks that rely on Indigenous values.

Anticolonial proposals made from settler contexts in the Global South include: a) situating the regulation of genetically modified seeds in modernist ontologies that marginalize alternative ways of knowing (Whittingham et al. 2024); b) countering neoliberal claims of individual ownership over seeds by accounting for modern agriculture's displacement of Indigenous seeds and associated agricultural practices (Jimenez et al. 2022). Resulting deskilling and loss of knowledges are challenged through struggles for on-farm restoration of genetic and epistemological diversity, led by Indigenous and other smallholders (Montenegro de Wit 2016).

Decolonizing technology assessments?

Struggles for epistemic diversities, may entail the refusal of modern innovations that harm the same diversities. This refusal is more than just resistance to specific modern technologies, it is also a political choice to embrace alternative techniques (Van Dyck et al. 2022). Refusal is thus simultaneously "a movement of exit and a process of invention" (Weeks 2011, p. 100). Refusals of biotechnological, digital, chemical and aerial technologies in modern agriculture may seek to sustain alternatives: 'traditional' seeds, animal manures, smallholders' land rights and cultivation practices, and Indigenous, artisanal and agroecological ways of

knowing (Arora and Van Dyck 2021). Refusals may therefore be acts of radical care towards other worlds providing social-material bases to diverse ways of knowing and practices of living with lands, seeds, water and more.

The notion of radical care builds on feminist and Indigenous struggles that center life, while resisting and healing from violent predations of modern ‘resource’ extraction (Sultana 2022). Radical care is thus not only about countering (eco)modernisation that damages colonially marginalized worlds (Hobart and Kneese 2020), but also about practicing solidarity with alternative ways of knowing. It is by using these alternative ways that colonized peoples have historically made many worlds of life-sustaining practices (Portocarrero Lacayo 2024). Moving beyond colonial relations between nations and cultures, radical care challenges modernity’s colonial encounters with other worlds across the Global South and North (de la Cadena and Blaser 2018).

In dismantling of colonial relations thrives the hope that many worlds can undergo reparations to flourish together in divergence.

Being more than just nations and cultures, social-material worlds involve deeper ontological foundations of ways of knowing (de la Cadena and Blaser 2018). Thus, Indigenous, artisanal, agroecological and industrial ways of knowing are not simply different epistemological cultures approaching the same ‘nature’ and grasping the same reality, but rather they help make many realities. In some ontologies underpinning such ways of knowing, the modern category of ‘nature’ divided from cultures might not even exist. A diversity of such ontologies is associated with Indigenous peoples and other artisanal and agroecological communities. It is the making of many worlds through such ontologies, that is obscured by colonial relations that privilege modern categorial divides of nature vs. culture and subjects vs. objects (Escobar 2020). Thus, many worlds as variously entangled ‘culture-natures’ – based on diverse ontologies – are either marginalized or assimilated by colonial modernity.

Allying with Indigenous, artisanal and peasant struggles to stop damage and exploitation of their land and ‘resources’, we articulate radical care as challenging colonial modernity’s six constituting relations (Arora and Stirling 2023). We propose that this six-fold challenge be made central in TA, to help imagine and enact reparations for colonially marginalized and damaged worlds.

Modernity firstly works through assumptions of its technosciences’ superiority – often based on its claims to singular objectivity – over artisanal and agroecological ways of knowing based in indigenous and other colonized worlds (Arora and Stirling 2023; Ajwang et al. 2023). Where such ways of knowing are acknowledged as valuable, focus can be on their integration into modern technosciences. Grounds for such assimilation may be strengthened if modern technosciences are re-framed or

re-legitimized as responsible and just innovations (Ludwig and Macnaghten 2020).

Modernity’s integrative and assimilative tendencies must be situated in pasts and present of colonial appropriation of artisanal, ecological, economic, epistemological and spiritual privileges from colonized worlds (Arora and Stirling 2023). Without confronting and dismantling modernities’ constituting appropriations, calls for integration (of Indigenous knowledges for example) and even for epistemic diversity in sustainability transitions (Balanzó-Guzman and Ramos-Mejia 2023), can further concentrate power and privilege in the modern world at the expense of other worlds.

Similar to appropriations, colonial relations enact modern powers’ extraction from other worlds. Objects of this toxic extraction are all kinds of materialities associated with land (above and below the ground), labour, water, knowledges and cultural

symbols (Gómez-Barris 2017). These may then be translated into modernity as resources for monocultural plantations and wider industrial agricultures (Kröger 2021). At the same time, modernity’s material messes such as toxic wastes, trails of industrial agriculture and cheapened products are dumped on marginalized communities and worlds (Patel and Moore 2017). Without confronting such relations, participation of plural perspectives in TA can serve to hide and inadvertently legitimize colonial modernity’s toxic-extractive relations.

Extractive relations are underpinned by colonial fantasies of control. These are enacted not only on categorically divided modern ‘nature’ and racialized people othered by national and cultural borders (Arora et al. 2020). They are also enacted on entire worlds. Such relations may involve the deployment of surveillance and enumeration technologies, to fence and survey Indigenous and colonized worlds as ‘reservations’ or ‘protected territories’ (West et al. 2006; Mamdani 2020). Socio-material change in these worlds may also be controlled and managed by modern (agricultural) development and conservation experts.

Border zones between worlds may be technologically militarized, also in order to facilitate the appropriation of plants, trees and extraction of land (e.g., in Amazonia: Domingues and Sauer 2023). It is through technologies of extreme violence that moderns assert military supremacy over other worlds (Arora and Stirling 2023, pp. 7). By neglecting colonial violence of military supremacy, mainstream TA fails to check the damage and destruction wrought on other worlds by modern societies.

Crucially, colonial relations mean that modern definitions of genders (including associated roles) are imposed on other

worlds (Oyewumi 1997; Lugones 2007). Such imposition may involve the definition of binary categories of men and women as ‘universally’ applicable roles in any society, thereby promoting and enforcing modern forms of gendered domination. This can include attempts to assimilate colonially marginalized ways of living into modern ones using promises of gender equality, while modernity itself remains replete with intersectional oppressions of racism, Islamophobia, classism and sexism (Ahmed 2024).

Attending to this coloniality of gender in TA efforts may entail the recognition of *infra-sectionality* (Arora and Stirling 2023), in which race, religion and class are not approached as separate ‘sections’ that exist *a priori* and then intersect with categories of gender. Instead, each gendered ‘section’ is constituted from within by a heterogeneous tangle of colonial relations (such as those discussed above). The same recognition then highlights a commitment to deep relational egalitarianism to be made central in TA concepts and methods of all kinds, also through solidarity with wider movements and struggles for confronting and transforming colonial modernities. Such solidarity might involve making central in TA processes, decolonial movements’ critical appraisals of innovations like artificial intelligence and genome editing (including their uses in agriculture), especially as those innovations are hyped up by modern powers as ‘the future’.

Conclusions

Ongoing colonial relations amidst widespread socio-ecological crises mean that TA efforts must help foreground *radical care* for indigenous and other colonially marginalized ways of knowing and being. Firstly, this entails supporting *refusals* of modern innovations through TA, where they are appraised as carrying possibilities of damaging colonized worlds that provide social-material bases of marginalized ways of knowing. More concertedly, making radical care central in TA methods and concepts means practicing solidarity with decolonial movements that directly challenge deeply entrenched colonial relations. Such relations can otherwise remain largely the same while making a whole range of modern innovations and the wider modern world.

None of the six colonial relations discussed above, is a discrete entity that works on its own. Because these relations are entangled with each other in different ways across the Global South and North, directing attention to just one relation (e.g., to counter assumed techno-scientific superiority in support of epistemic diversity, or oppose imagined control to promote technosciences based on values of care) can fail to check the unabated continuation of other colonial relations. The relations that remain unfaced and untransformed can weave back into the focal relation that is confronted, thereby thwarting the singular decolonial transformation that is attempted. Confronting any focal colonial relation must therefore address other relations that are directly entangled with it.

Decolonial transformations of TA thus go far beyond embracing epistemic diversity or techno-scientific pluralism (through precaution and participation), because diverse epistemologies and plural techno-scientific directions can still be encompassed by colonial modernity. Such transformations are about dismantling the web of entrenched relations that continue to make colonial modernity more and more globally hegemonic. In such dismantling of colonial relations thrives the hope that many worlds can undergo reparations to flourish together in divergence. Without contributing to this pluriversal flourishing, TA risks remaining a civilizing instrument of colonial modernity.

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RESEARCH ARTICLE

Careful handling of marine plastic litter: Technology assessment and care

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Abstract • Waste is a core concern of today's societies. A prominent example is marine plastic litter, which has devastating impacts on ocean ecosystems. But: How can technology assessment (TA) support a careful handling of plastic waste in the sea? And what can care concepts contribute to the practice of TA in this context? In this article, I show that care concepts can help understand the complexity of waste management as well as the environments involved, regulation processes, and technical innovations. Moreover, care concepts could benefit TA practice by sensitizing it not only to cultural, regional, and global concerns, but also to the distribution of responsibility and marginalization processes.

Sorgsamer Umgang mit marinem Plastikmüll: Technikfolgenabschätzung und Fürsorge

Zusammenfassung • Abfall ist ein zentrales Problem der heutigen Gesellschaft. Ein prominentes Beispiel ist der Plastikmüll in den Meeren, der verheerende Auswirkungen auf die Ökosysteme der Ozeane hat. Aber: Wie kann Technikfolgenabschätzung (TA) einen sorgsamen Umgang mit Plastikmüll im Meer unterstützen? Und was können Fürsorge-Konzepte dabei zur TA-Praxis beitragen? In diesem Artikel zeige ich, dass Konzepte der Fürsorge helfen können, die Komplexität der Abfallproblematik sowie die damit verbundenen Umwelten, Regulierungsprozesse und technischen Innovationen zu verstehen. Darüber hinaus könnten diese Konzepte nützlich für die TA-Praxis sein, indem sie sie für kulturelle, regionale und globale Belange, aber auch für die Verteilung von Verantwortung und Marginalisierungsprozesse sensibilisieren.

Keywords • global TA, care, plastic waste, marine litter

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Introduction

Waste is a core concern in today's societies. One example for waste is waste in the ocean. The marine area has gained prominence lately as part of the UN Ocean Decade which started in 2021. Marine waste, also called marine litter or marine debris, consists of variously sized objects, such as ropes, bottles, cans, fish nets and plastic and microplastic particles, the latter representing a substantial fraction of marine waste. Marine litter floats and drifts around – seemingly endlessly as it is submerged and diluted within the vastness of the deep oceans – before it ends up in the deep sea or on the shorelines. Thus, marine litter is not confined to one area but dispersed throughout the oceans on earth, creating a global problem. At the same time, marine litter is not always necessarily visible to humans as a substantial amount resides in spaces largely inaccessible to human intervention, such as the deep sea. In this article, I highlight marine plastic litter, a material which has undoubtedly risen to some fame in the last decade and argue, that care can serve as a tool in technology assessment (TA) practice to reflect on the complexity of global environmental problems. Here is why:

Estimations claim that the global human-made mass of plastic exceeds the living biomass by double (Elhacham et al. 2020). These and other estimations (report from World Economic Forum et al. 2016) have brought plastic into a questionable limelight of attention and characterized it as remnant of socio-technical innovation. Plastic objects are produced as part of a promising innovation and are part of a variety of infrastructures and related practices, from household items to mobility technologies. At the same time, plastic objects often end up on landfills, in rivers and last but not least, in the sea. Once in water or deep in soil, plastic is hard if not impossible to trace or recycle. For example, as soon as plastic litter enters the marine environment, it interacts with the marine ecosystem and marine life. It is often ingested by

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marine life or entangled with it, for example when ropes or packages lead to physical harm or when small plastic particles exert ecotoxicological effects due to leaching its components. Based on this, leading marine scientists have framed marine plastic litter as a core global environmental problem (Napper et al. 2021; Bergmann et al. 2015). Similarly, societal stakeholders, non-governmental organizations, policy makers and citizen groups identified marine plastic litter as highly problematic. This problematization has led to political incentives and to a plethora of technological innovations focused on cleaning the ocean, rivers and streams. ‘Horizon’, the European Union’s Research and Innovation Magazine featured some technological innovations in 2022, among them cleaning robots for picking up waste on the shorelines, cleaning technologies for big and small plastic objects or mobile application for the detection of litter (Willmer 2022). But although technical innovations for combating marine litter are assessed (Bellou et al. 2021), it still needs to be figured out which solutions might work best and for whom and where, who are the societal stakeholders that care about marine plastic litter and how this can be done in a global manner.

cepts are capable of attending to marginalized places, spaces and voices (Puig de la Bellacasa 2010, 2011, 2015) and allow to think about “everything that we do to maintain, continue and repair ‘our world’ so that we can live in it as well as possible” (Tronto 1993, p. 103). Attending to care is insofar relevant, as the ocean is currently featured as carbon storage space crucial for humankind and its survival. This scenario is however only possible with an ocean that is not constantly polluted and in danger but an ocean that is resilient. New technological innovations, global alliances and policy measures for a less polluted ocean will need to be reflected on by TA scholars in the future.

Conceptualizations of care

Care represents a core concern in many social science disciplines. Prominent scholars, such as Mol (2008), Moser and Pols (Mol et al. 2010) and Puig de la Bellacasa (2010; 2011), have brought the notion of ‘care’ into the center of interest in different communities, among them Science and Technology Studies, a scientific

Leading marine scientists have framed marine plastic litter as a core global environmental problem.

All these contexts make marine litter an important case for TA practice and its focus on political decision-making processes, enabling a broad societal discourse on technical innovation and their effects, among them for example through participatory processes including different societal stakeholder groups (Grunwald 2002). This is even more so for TA practice that explicitly discusses human-made problems on a global scale (Böschen et al. 2021; Hennen et al. 2023). The global dimension of marine plastic litter also resembles other waste debates, among them in TA practice and its concern with nuclear waste (Töpfer and Ufer 2019; Hansson 2022), concerns that involve various stakeholders dealing with environmental concerns. The global character of marine litter, its different forms and formats and its presence in different ecosystems such as the ocean surface or the deep sea, as well as its different sources, however create a conceptual challenge, that I suggest can be tackled with the concept of care. I ask:

How can technology assessment scholars care for marine plastic litter and what can care concepts add to technology assessment practices?

I highlight care as my conceptual take for the enrichment of TA practices by thinking along the complexity of marine plastic litter, efforts for its regulation and socio-technical innovations for its removal. Specifically, I argue that a focus on care can be particularly fruitful for TA practice that focusses on global environmental problems such as marine plastic litter. Care con-

community on whose work I largely draw on. A prime example of work on care and its conceptual impact is that of Puig de la Bellacasa who demands an understanding of care that allows to see “how things would be different if they generated care” (2011, p. 96). In calling for a speculative commitment for “situated and positioned visions of what a liveable and caring world could be” (2011, p. 96), she calls for engagement beyond normative interventions and awareness for oppressed and neglected experiences that create oppositional positions. Thereby, Puig de la Bellacasa aims to unpack relationships along a focus on marginalized and excluded voices, in order to “not only (to) expose or reveal invisible labors of care, but also to generate care” (2011, p. 94). In this sense, care not only allows to analyze care practices but also unpacks who engages in care practices, who is left out or marginalized. Applied to the case of marine litter, the concept of care can open up what often stays hidden, such as the occurrence of marine litter in different spaces, the deep sea or the ocean surface, spaces that need different interventions and regulations. Moreover, marine litter comes in different shapes and sizes while representing a fundamental global phenomenon. Hence, a focus on care can not only monitor who is affected but also who cares and how. This speculative commitment could then re-orient research on and technological innovations to combat marine litter as it could unpack the complexity of marine litter.

Next to this conceptual sensitivity, Murphy (2015, p. 721) characterizes care along four main meanings: “[F]irst, it refers to the state of being emotionally attached to or fond of something;

second, it means to provide for, look after, protect, sustain, and be responsible for something; third, it indicates attention and concern, to be careful, watchful, meticulous, and cautious; while its fourth meaning [...] is to be troubled, worried, sorrowed, uneasy, and unsettled.” Taking up Murphy’s characterization of care, I have previously developed the notion *environmental care* (Schönbauer 2024), a concept that allows to understand care for environmental changes on individual and collective level based on the premises of emotional attachment, responsibility, attention and concern as well as the worries and uneasiness that environmental harm invokes for those studying them and those affected by it. In this sense, care can provide a speculative commitment for affectedness, for relationships with an empirical concern, for researcher responsibility and attentiveness towards a global phenomenon and its complex ramifications.

Marine plastic litter as a concern for TA

Since marine plastic litter is a global problem that cannot be confined in place nor time, its global character resonates with recent calls from TA scholars, namely that TA practice concerned with environmental problems needs a global agenda. Böschen and colleagues (2021) identify the need to account for the global dimensions and complexity of global human-made problems as a core challenge for TA practice. Hennen and colleagues (2023)

and its occurrence in different shapes and sizes, but it can also help to understand the difficulties of regulatory processes in the marine area. In the following, I will attend to some aspects of marine plastic litter that showcase its complexity and how it can be understood with care.

Marine plastic litter: a complexity

Marine plastic litter often resides in spaces that are not immediately accessible for humans. Objects dis- and re-appear from the global ecosystem and travel in time and space with an inherent there-but-not-there quality. A prominent example for marine plastic litter is the Great Pacific Garbage patch, a huge accumulation of marine litter in the Pacific. It is a space that is out of reach for most humans while full of marine life and plastic objects. De Wolff (2014) has for example shown how marine life uses plastic objects as habitat in the open sea. Fish and other animals find shelter in these objects and small plastic objects travel with them. At the same time, plastic litter has toxic and harmful effects on this ocean sphere. Based on the entangled nature of marine plastic litter and marine life, Bergmann (2019) has argued that care is a crucial concept to think with. Care can mean to relieve the ocean ecosystem from an anthropogenic marker when removing plastic litter. Yet, care can also result in marine life being denied an infrastructure that it got used to. Thinking with care then means to focus on the relationships that marine plastic litter creates with marine life.

Care can provide a speculative commitment for affectedness.

also argue that the inherent global characters of many current problems call for international connection to reflect on technological innovations. The need for international connection that TA scholars argue for, is tangible for example in political regulation processes for marine plastic litter. The identification of marine areas in need of protection already happened in 1974, when the United Nations Environment Programme (UNEP) has launched a Regional Seas Programme in order to protect marine and coastal environments. This programme brought together various stakeholders and also addressed marine litter. Later on in 2022, UNEP adopted a resolution to develop a legally binding mechanism to stop plastic pollution, the so-called ‘Plastics Treaty’, a resolution which was considered a break-through for the future of the ocean (UNEP 2022).

Connected to the need for global alliances in global TA, Hahn and Ladikas (2021) call for new conceptual and methodological approaches that assist the need for “urgent global coordination” and “identify, assess, discuss and regulate the impacts (e.g. societal, environmental, ethical or legal)” of technological innovation (Hennen et al. 2023, p. 5). I argue that care can serve as a tool in TA practice to reflect the complexity of global environmental problems. Care can for example help to make sense of marine plastic litter specificities, such as its inaccessibility in some areas

Connected to care for marine life and litter entanglements, care can also open up affectedness. Thinking along marine plastic litter with care needs to take into account human and more-than human entities, both being affected differently by plastic objects. If taking into account marine life and its entanglement with marine plastic litter as well as environments out of human-inhabited worlds, care can mean to focus on affectedness beyond human-centered interpretations (Lindén and Lydahl 2021), an important reframing for environmental problems. Thereby, TA scholars can attend to emotional attachment, protection and responsibility, attention and concern, but also take into account who is being troubled and worried by the presence of marine plastic litter. This shift in focus could serve TA practitioners to attend to the complexity of affected marine life, to the relations being made. Marine plastic litter then results as a complexity rather than isolated problem.

Connected to these sensibilities is the existence of marine plastic litter on different scales: small and big. Considerable proportions of marine plastic litter exist invisibly as microplastics (Thompson et al. 2004; Liboiron 2019; Bergmann 2021). While slowly breaking down to microscopic size, plastic residues of various origins become not only invisible, but also untraceable and descend to considerable oceanic depths. Meanwhile, big

plastic objects can potentially be removed from the ocean, although only in extremely costly undertakings (Galgani et al. 2010). An example for this is the Ocean Cleanup, an organization featuring a technological device invented by a team around Dutch entrepreneur Boyan Slat (The Ocean Cleanup 2024). This approach has been criticized by marine scientists based on the entanglement of marine life with marine waste and the lack of discrimination between individual plastic objects and those that are inhabited by marine life. While such technofixes contain the

took into account marginalized voices is the fifth session of the UN Environment Assembly (UNEA-5.2) which took place in March 2022. UNEA-5.2 was historic insofar as it was the first step towards creating a binding agreement for the regulation of plastic waste – including the marine area. Later in 2022, a multi-stakeholder forum was being implemented, including scientists, finance sector representatives, civil society groups, indigenous people and youth representatives. This also resonates with the written resolution published in March 2022 stating the impor-

Thinking with care then means to focus on the relationships that marine plastic litter creates with marine life.

illusion of re-gained purity, they come at profound costs when not including a more than human reflexivity. Thereby, marine plastic litter also challenges Western concepts of pollution, specifically those of repair and purity (Shotwell 2016; Liboiron 2016) and demands different forms of technological innovation beyond human-centered imaginations on an environmental problem.

These sensibilities connect to arguments in global TA that urge TA practice to move beyond traditional Western concepts. For one, Ely and colleagues (2011, p. 21) state, that TA has to become more “transnational, networked, virtual and flexible” in order to stay attentive to global environmental problems and that Western concepts do not necessarily fit into every cultural and regional context. On the other hand, Hahn and Ladikas (2021) similarly formulate a main challenge for global TA: to dedicate work to national as well as global contexts and regional concerns. One example when thinking with care along marine plastic litter is the attention towards differing cultural practices. For example, plastic waste can land on shorelines and be considered aesthetically distortive, thereby becoming part of purification measures such as beach cleanups. At the same time, plastic containers can be used with extreme care, such as in household practices, when they are repurposed to contain food sources and thereby creating socio-material configurations and novel relational possibilities (Dey and Michael 2021). Thinking with care can open up a reflection on plastic objects in relation to powerful asymmetrical relationships, those created by international commodity chains and international and national waste infrastructures. Thinking with care also allows to reflect on marine plastic litter and its different forms, formats and inhabited environments and thereby highlight the relations plastic objects build before entering the ocean, when landing on the shorelines, or when residing in inaccessible oceanic depths.

Marine plastic litter and regulation

Connected to marine plastic litter and its complexities, TA practitioners and care scholars argue, that marginalized voices and communities often stay invisible but might be affected most, such as by residues of waste. An example for an event which

tance to recognize “workers in informal and cooperative settings to the collecting, sorting and recycling of plastics in many countries” (UNEP 2022, p. 3), such as waste pickers, island communities and fisheries. The involvement of marginalized voices is symbolic for how waste resembles a global matter yet needs to be reflected along regional and cultural contexts. For example, it is crucial to highlight the different contexts of affected communities. Fishers working on the shorelines are economically dependent on their profession and the well-being of fish habitat, while waste pickers are exposed to toxic chemicals when caring for inland recycling infrastructures, often informal ones (Schlitz 2020). And island communities are particularly vulnerable to marine plastic litter (Lachmann et al. 2017) as they are challenged with its ecological effects, are dependent on coastal tourism or limited in their prevention strategies. Hence, emotional attachments vary as well as measures for protection, responsibility distributions and how the different communities are troubled and by what.

Along these differences, the negotiation processes of UNEA-5.2 offers insights into the challenge to include societal stakeholders along their different aims. For example, Melanie Bergmann, a German marine scientist, attended the fourth meeting in Ottawa in spring 2024. She narrated the difficulty of including the whole life cycle of plastics, such as derivatives and chemicals, into regulation practice and the importance yet marginalization of voices from scientific communities (Bergmann n.d.). Hence, not only affected communities but also those researching the impact of marine plastic litter are challenged for their expertise being heard. This is also based on the different key motivations to tackle plastic pollution dependent on agenda prioritizations from societal stakeholders, posing challenges for the development of a binding instrument (Knoblauch and Mederake 2024). Hence, there is no unified interpretation of care for marine plastic litter yet. Related to this struggle, TA scholars argue that different forms of expertise need to be accounted, that different stakeholders and social groups need to be included and that reflexivity needs to be effectively integrated in TA processes (Ladikas and Stamm 2023). A focus on care can add to this

reflexivity and help understand whose voice (and research) is marginalized and which stakeholders remain absent from environmental regulation processes.

Another dimension often left aside is the affective dimension. As “attentive experimentation” (Mol et al. 2010, p. 13), care opens up a feminist standpoint of sociotechnical issues, as they demand a particular “thinkpolitics” (Puig de la Bellacasa 2011, p. 94) that includes a socio-political diagnosis of the affective dimension. Highlighting the affective dimension means to focus on an “affectively charged sensibility characterized by worry, attentiveness, and thoughtfulness” (Martin et al. 2015, p. 629). This sensibility can then mean to engage closely with neglected toxins and invisible chemical residues leaching from plastic litter as proposed by the scientists, or including voices of non-governmental organizations and communities of local fisheries with differing worries. It also means to take into account and relate regional, national and international concerns and foster future meetings and regulation practices that include various societal stakeholders, showcase their expertise, but also their (varying) environmental concerns.

Conclusion

I have started by asking: How can TA scholars care for marine plastic litter and what can care concepts add to TA practices? I argue, that marine plastic litter demands a notion of care that takes into account different voices, spaces, times, governance regimes, policies, regional, national and international contexts. Marine plastic litter also demands a sensitivity to its appearance in different forms, formats and spaces, its large inaccessibility and invisibility but also its omnipresence, characteristics that make regulation processes and just technological innovations difficult.

I have shown that thinking with care on this matter allows to understand the complexities of an environmental problem, such as more-than human relationships, the re-definition of pollution in the omnipresence of plastic objects, and affectedness in and marginalization of social groups. A focus on care is thus important to understand technological innovations that promise to tackle marine plastic litter, in order to see whom they help, whose voices and concerns they leave out. This could for example mean to challenge current plastic production processes and demand policies for just and effective cleaning technologies (Bergmann et al. 2023) or to think about alternative product innovation and to rethink commodity chains. Thinking with care is also important regarding regulation practices and affected communities and to reflect on the potential selective attention that regulation processes bring with. I argue, that integrating care as conceptual tool responds to the call for conceptual enrichment in TA practice of how we can best attend to the socio-technical challenges of future times (Böschchen and Dewald 2018). An *environmental care* for marine plastic litter could open up “the complexities of caring in turbulent times with regards to po-

tential catastrophic events lingering in the future and cases of destruction or variable harm that reside in the past and present” (Schönbauer 2024, p. 18). Reflecting with care and focusing on *environmental care* could assist TA practitioners by helping to sensitize TA practice towards emotional attachment, responsibility, attention and concern and environmental uneasiness, core characteristics of care that open up “neglected experiences that create oppositional standpoints” (Puig de la Bellacasa 2011, p. 96).

It seems imperative for global environmental problems to be reflected along care concepts and analyze negotiation processes, marginalized and present actors, but also the distributed responsibilities, affectedness and worries that they bring with. This is all the more important in view of the global nature of marine plastic litter and the debates on environmental justice at global, international, national and regional level.

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RESEARCH ARTICLE

Technology or practices of care first?: Technology assessment in the tension between ‘technology push’ and managing socio-technological futures

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Abstract • The article underscores the crucial role of technology assessment (TA) in balancing technological development with care principles. While TA integrates care-based approaches, it is evident that these efforts alone are not sufficient to promote truly ‘caring’ societies. Technological solutions are often insufficiently tailored to the specific needs of users and the social contexts of care, creating significant tensions. The article therefore argues for a ‘care-sensitive’ TA that not only ensures technological robustness and adaptability but also allows continuous ‘tinkering’ to refine technologies in dynamic care settings. A reciprocal, contextual approach benefits both caregivers and recipients by embedding technology into care practices rather than subordinating care to technological imperatives.

Technologie oder Pflegepraktiken – was kommt zuerst?: Technikfolgenabschätzung im Spannungsfeld zwischen ‚Technologie-Push‘ und dem Management soziotechnischer Zukünfte

Zusammenfassung • Der Artikel beleuchtet die zentrale Rolle der Technikfolgenabschätzung (TA) im Spannungsfeld zwischen technologischer Entwicklung und Fürsorgeprinzipien. In der TA gibt es zwar fürsorgeorientierte Ansätze, es zeigt sich jedoch, dass diese Bemühungen nicht ausreichen, um wirklich ‚fürsorgliche‘ Gesellschaften zu fördern. Technische Lösungen sind oft zu wenig auf die spezifischen Bedürfnisse der Nutzer*innen und die sozialen Kontexte der Pflege zugeschnitten, was zu Konflikten führt. Der Artikel plädiert daher für eine ‚fürsorgesensi-

ble‘ TA, die nicht nur technische Robustheit und Anpassungsfähigkeit gewährleistet, sondern auch einen kontinuierlichen ‚Tinkering-Prozess‘ zur Abstimmung von Technologien auf dynamische Pflegekontexte ermöglicht.

Keywords • technology assessment, care approaches, STS, healthcare, assistive technologies

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Technology or practices of care first?

From its very beginning, technology assessment (TA) has consistently encompassed a wide spectrum of conceptional theories reflecting on, observing and implementing various ‘care’-based issues. These theories include the precautionary principle as a guiding anchor of TA (Bechmann 1994), the discourses on Responsible Research Innovation and TA (Bogner et al. 2015) and the extensive scientific work on sustainability and TA (Parodi et al. 2022). So, throughout its history, TA has emphasized and expanded upon a multitude of care-related aspects such as the sensitive handling with technical development, the consideration of multiple interests of social groups in TA-activities and the protection of ecological environment. Hereby, from our point of view, care-based issues have been included into an inclusive and participative approach. In doing so, Grunwald strengthens the process-oriented side of TA in his publications (Grunwald 2019). He emphasizes the importance of normative premises of technical developments, we consider as important notions of care implications: “[. . .] Hence, technology assessment is indeed more than technology assessment: it is both an experi-

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mental practice and a field of reflection addressing issues of an anticipatory, inclusive, and complexity-aware society at large” (Grunwald 2019, p. 224). In practice, TA activities have been reflected by normative premises like the ‘Sustainable Development Goals’ of the United Nations (United Nations 2015) and the concept of responsibility. These principles should play a significant role in technological fields such as energy transition, digital infrastructure, and the implementation of robots across societal domains (Böschen et al. 2021). Considering these factors, TA contributions enhance the care of environmental issues, the care of social diversity and social empowerment as well as the care of ethical-based visions with regard to technical futures. Although these approaches do not implicitly contribute to the Feminist-based concept of care (Tronto 1993), we argue to open up TA approaches with those concepts. Due to actual capitalistic dynamics and their impact on planetary crisis (Block 2020), this seems specifically coherent.

In the last years, scientific projects in different thematic fields of TA demonstrates that the implementation and the assessment of new technologies are strongly influenced by their functions within political, cultural and economic settings, their embedment into capitalistic-based organizations, and the anticipated objectives of technological achievements (Krings et al. 2021). For instance, the ongoing debate on artificial intelligence (AI) illustrates significantly the need to address various care qualities in diverse social settings as exemplified in Kirchschräger’s work (2017, p. 240): “[. . .] beyond that, humans with disabilities are empowered to live an autonomous life; surgeons can delegate routine tasks of their daily professional life in order to devote more time to their patients and to research; self-driving vehicles do not drive drunk, angry or tired, and therefore create fewer accidents [. . .]” (translation by authors). The notion of care focusses here on human interactivity in democratic-based institutionalised settings, caring personal rights and integrity of humans in this context. This perspective is clearly anthropocentric and refers to an “reflexive agency” (Conradi 2001, p. 59) and shows certain limitation with regard to latest care concepts, discussed intensively in public. These concepts refer specifically to global health issues (Kimmerer 2021).

As shown above, TA has implicitly addressed several aspects of care in its conceptual approaches since its inception. Nevertheless, there are limits when it comes to the normative indicators of an ‘ethics of care’ (Tronto 1993, further refined in Mol 2008; Mol et al. 2010). Mol and her colleagues’ understanding of care is based on ‘Feminist Theory’ and ‘Science and Technology Studies (STS)’, which underline the generative and creative character of care (Mol 2008). Conversely, the empirical research and observations propose the idea of care as ‘tinkering’ in several societal spheres and everyday life (Mol et al. 2010). Thus, according to Mol et al. (2010), in socio-technical contexts, ‘tinkering’ should be seen as a distinctive mode of social and scientific practice that is particularly suited for socio-technical environments. Based on this preliminary work by Mol (2008) und Mol et al. (2010), the authors of this article advocate in the

following for an explicit development of a normative approach of an ‘ethics of care’ in TA approaches. We suggest that such a strategy can provide guidance in specific socio-technical settings. By doing this, the social, cultural and political quality of these socio-technical spaces undergo a substantial transformation and enrichment. In this regard, the concept of ‘justice’ can be reflected by other norms like fairness, kindness or generosity (Mol et al. 2010). And by implementing caring practices, new future visions of work and life circumstances would be implied. Issues such as reciprocity and/or the respect to and for the accomplishment of everyday life would be – step by step – systematically elaborated for and discussed also within specific socio-technical contexts.

With this in mind, we start our considerations with different perspectives on caring practices referring inter alia on the approach of ‘ethics of care’. Our approach aims to identify the distinct quality necessary for the social and cultural progress of present-day societies. However, we acknowledge that healthcare systems vary significantly across societies, even among culturally similar ones, shaping the organization and provision of care in ways that reflect these societal distinctions. In the next part, we provide the use of care-based issues in TA efforts, drawing on exemplified observations in the healthcare sector. Here, it becomes evident that fields of tensions arise when normative premises of an ‘ethics of care’ are not explicitly defined from the outset in TA. These tensions will serve as the foundation for the concluding remarks. We argue that technical advancements should be more deeply embedded into the approaches of future ‘caring’ societies, as this concept implies that all care practices should be integrated into a societal setting. Within this social framework, citizens then have the “right to give and to receive care” (Beckmann 2008, p. 69).

Caring practices from different perspectives

“Care of children, the frail elderly, husbands, the handicapped, and the sick is not by definition paid or unpaid. Care is paid or unpaid as a consequence of political choices, shared cultural beliefs, and gender structures.” (Knijn and Kremer 1997, p. 330)

Due to the well-defined double crisis of ‘care’ that almost all high-industrial societies experiencing, care-based issues have gained significant importance. This focus of attention, on the one hand, criticizes the drawbacks of capitalistic logic and, on the other hand, provide pathways towards ‘solidary societies’ (Winker 2015; Von Redecker 2020). Already in the 1970s, Feminist Theory based on the work of the philosopher and economist Karl Marx (1818–1883), figured out that functionality of capitalism depends strongly on the ‘reproductive’ part of an economic system. However, it is worth considering that biopolitical measures to maintain system functionality are not exclusive to capitalist societies. Non- or semi-capitalist systems also employ

such strategies to ensure their systems' 'sustainability'. From this perspective, it is essential to regenerate human work as a productive factor to ensure its availability for long-term industrial processes (Knapp and Wetterer 2003). Reproduction, in the context mentioned, refers to the 'other' and mostly overlooked or marginalized aspect of economic-based production. It encompasses all activities of regeneration in individual households, such as cooking, cleaning, gardening, caring children and el-

publicly discussed during the Corona Pandemic from 2019 to 2021. Likewise, due to the enactment of pandemic regulations the great variety of institutional and individual care activities were entailed a "specific *modality* of handling questions to do with the good. [...] In the ethics of care, it was stressed that in practice, principles are rarely productive. Instead, local solutions to specific problems need to work out" (Mol et al. 2010, p. 13; emphasis in original).

In Germany, the significance of care work, both formal and informal, has been and continues to be undervalued in terms of political, societal and financial recognition.

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derly people which are the precondition per se for sustaining the economic system (Becker-Schmidt 2002). The women's role as caregiver goes back to the emergence of fundamental new forms of division of labor during the Industrialization period. During this time, women were "expected to take responsibility for the health and safety of the entire family in and around the home" (Huws 2003, p. 38). At the same time, there arose a societal and political imperative to improve the living conditions of workers as well as to prepare them for the labor markets. Offering basic education and occupational training enhanced the level of qualifications in the work force. Step by step, the implementation of healthcare, (higher) education, and day care as components of social infrastructure in the establishment of welfare states in Europe resulted in the formation of distinct 'care-regimes' (Beckmann 2008; Esping-Anderson 1990; Daly and Rake 2003). These regimes have varied and still differs

"according to the 'care arrangement' approach [...], the structure of welfare mix in relation to care and the relationship of formal and informal care are embedded, in specific ways, into the institutional settings of welfare state, the labour market structures, family, the market, and nonprofit organizations [...]." (Pfau-Effinger 2005, p. 23)

In Germany, the significance of care work, both formal *and* informal, has been and continues to be undervalued in terms of political, societal and financial recognition. This lack of awareness results to disadvantages for women in paid and unpaid care work situations (Winker 2015, 2021). Besides this, the economization of the healthcare sector (Manzei and Schmiede 2014), including e.g. the privatization of healthcare and elderly care sectors along with the establishment of competition-based mechanisms, has led to increased cost for patients, and a shift in focus from patient needs to financial goals since the 1990s. Additionally, there has been monetary shortages, and a decline in the care quality. These changes have created a threatening momentum for institutional care arrangements (Bücker 2024), which was visible and

Building on this focus on localized, context-specific solutions¹, the care approach has, over the last decades, been expanded — particularly under the influence of Anglo-Saxon scholars — to incorporate concerns about environmental issues such as the depletion of natural resources, climate change, and the link to the material environment (Kollewe et al. 2017). So, their understanding of care not refers exclusively to interpersonal relationship, but also the notions of maintenance, conservation and valuing of environmental conditions. One prominent approach is proposed by political scientists Berenice Fisher and Joan Tronto (1990, p. 40), who argue that caring should be understood

"[...] as a species activity that includes everything that we do to maintain, continue, and repair our 'world' so that we can live in it as well as possible. That would include our bodies, ourselves, and our environment, all of which we seek to interweave in a complex, life-sustaining web."

Although Fisher and Tronto's expansive definition of care may appear broad and lacking in specificity, this often-quoted perspective nicely reconciles the divide between the intensive debate on care from a human, relational standpoint and the resource-based side of care, which includes all kind of environmental circumstances of humans such as nature, animals, materials (including technologies). These issues are explicitly discussed within the context of care in the field of STS (Kollewe et al. 2017). This debate has enormously gained importance in the 2000s and was further developed by the Dutch philosopher Annemarie Mol, who deeply analyzed the concept of care in medical practice (Mol 2008). Building upon Bruno Latour's work (Latour and Venn 2002), her research is centered around care practices, which inherently encompass technologies across all social contexts. By this regard, technology is not seen as the antithesis of

¹ While this focus on localized, context-specific solutions is crucial for addressing real-world problems, we recognize that it inevitably comes with limitations and non-transferability.

“nourishing” care (Mol et al. 2010, p. 14), but rather as beneficial tools individuals and institutions to actively participate in care activities:

“Technologies, what is more, do not work or fail in and of themselves. Rather, they depend on care work. On people willing to adapt their tools to a specific situation while adapting the situation to the tools, on and on, endless tinkering.” (Mol et al. 2010, pp. 14–15)

This connotation characterizes the Human-Technology-Relationship as dynamic rather than static, emphasizing the ‘endless tinkering’ process to discover ideal solutions with specific existing and individual contexts. The term ‘tinkering’ in this sense refers both, the public and private spheres at the same time. Furthermore, it pertains to the quality of care practices as a continuous process of learning and searching. According to Mol et al. (2010, p. 15) “[. . .] in care practices what it is to be human has more to do with being fragile than with mastering the world”. The act of self-identification as human seems to be the pivotal part of an ‘ethic of care’, which has a tremendous impact on the use and application of technology. The merit of this approach is the adaptability to every societal sphere to support social and cultural transformation towards ‘societies of care’. Nevertheless, in the following, we provide empirical evidence from scientific projects in TA. Here, we argue, that basically technology-first-approaches are in the focus of these projects.

exploration and introduction of care concepts, the primary emphasis is on technology. Moreover, this ‘technology-first’ logic indicates a lack of contextualization of technologies within care settings, therefore revealing an absence of care sensitivity. For instance, the empirical results of four TA studies (MOVEMENZ, 2014–2015; QuartrBack, 2015–2018; Compatibility of technology and networks in home care, 2014; JuBot, 2021–2026) demonstrate that technology development often fails to sufficiently consider the (potential) users of these technologies: Factors such as old age, fragility, forgetfulness, multiple doubts, anxieties, and personal preferences are frequently omitted. Issues that consideration would increase ‘care-sensitivity’ to high extend. This aligns with the findings of Lefint and Moniz (2024), who argue that if a product is claimed to support its users, it must be developed with their needs at the forefront to achieve this, raising questions about the role users play in the development.

However, the deployment of technologies revealed a noticeable lack of appropriateness, even with supposedly simple technical aids. For example, assistive devices like walkers, designed to ensure safety during while walking, were merely forgotten. Alternatively, people resorted to utilizing handrails, material carts, chairs, and various other objects as substitutes for walkers. The rollators themselves were left ‘parked’ due to the residents either forgetting about their existence or neglecting their intended purpose. In the QuartrBack project, a tracking technology was developed to maintain freedom of movement and independence. However, users often found the tracker overwhelming, and nearly

The (specific) social contexts of geriatric care are often overlooked or disregarded entirely during the process of developing the technology.

Care-based issues in technology assessment approaches – cui bono?

The ongoing discourse within both the scientific community and the general public on digitalization, robotics, and AI has placed significant emphasis on digital concepts in geriatric care (Heeser 2022). Technology is frequently advocated as a ‘care assistant’, often ascribed rather diffuse functionalities, including companionship for older adults, promises of safety, the preservation and enhancement of autonomy, and the creation of ‘more time for care’ due its perceived efficiency (Krings and Weinberger 2022). From the outset, technology is considered the main catalyst for change in the field of elderly care, with positive expectations being derived from the innovation potential of (new) digital and assistive technologies (Hergesell 2019; Hülsken-Giesler and Krings 2015; Weinberger et al. 2023). From the TA perspective, this approach give rise to substantial fields of tension, as the (specific) social contexts of geriatric care are often overlooked or disregarded entirely during the process of developing the technology. This implies that while the subject matter involves the

all individuals with dementia eventually forgot how to use it or even that it existed. This lack of alignment between the technology and the cognitive abilities of the users underscores a critical gap in the care sensitivity. Besides of this, for example, automated medication dispensing systems in care homes often lacks care sensitivity in its implementation. These systems are not adapted to residents’ individual routines and daily rhythms, potentially causing confusion and discomfort by imposing inflexible schedules that do not align with their personal needs.

Another field of tension arises from the TA perspective when considering the ‘environment’, as discussed by Fisher and Tronto (1990), particularly regarding the suitability of technologies to spatial conditions. Frequently, due to architectural realities, different aids were used because, for example, a walker could not be parked directly at the dining area, making its use more inconvenient for the residents. In another project, the humanoid robot bumped into an obstacle, either when crossing a threshold in the dining area or when it was blocked by a pillar in the common room. These examples vividly illustrate that when the ‘material’ (Fisher and Tronto 1990) is not well integrated into

the specific care setting, it can actually become an impediment to care, hindering rather than supporting the intended caregiving processes.

TA efforts conducted in various care settings also reveal that some stakeholders, such as the residents, professional caregivers, relatives, and volunteers, could indeed envision potential technical advancements that could improve mobility. However, care workers and volunteers immediately noted that the implementa-

tion of the technology would necessitate a substantial increase in time and resources. This is owing to the additional maintenance task, such as charging batteries, downloading updates, troubleshooting issues, managing data, and guaranteeing data protection. They found it difficult to envision how time could be set aside for these technological duties given the existing constrained schedules of care routines. Their emphasis was on ensuring that caregivers do not spend more time managing technology at the expense of providing care. In their opinion this would contradict the promise of utilizing technology to improve the efficiency of care work, which in turn allows more time to be dedicated to caring activities and enhancing the caregiver-patient relationship (Hergesell 2017).

Furthermore, the outcomes of the projects show that care processes are inherently dynamic, as they must e.g. consistently address the individual needs of care recipients and adapt to their changing health conditions. Moreover, the institutional embedding of care can have significant effects on the dynamics of care processes and procedures. This dynamism necessitates flexible, personalized and adaptive care interventions, as standardizing care concepts proves challenging given that each care setting has distinctive characteristics and residents have highly individual care needs. This also means, from a care-sensitive TA, that technological developments in care settings must not only be robust and adaptable. Additionally, they must but also be a socio-technical-institutional subject to continuous evaluation and improvement to meet changing care needs and evolving institutional frameworks.

These examples show roughly the importance of organizing the assessment and development of technologies through an open, dynamic, and contextualized scientific process that is both interdisciplinary and transdisciplinary. Such a process would help embed technological developments into care practices and not vice versa. For instance, this approach enables the integration of concepts of reciprocity, ensuring that the relationship between technology and care practices is mutually beneficial.

Such a care-sensitive approach to technology development, through its integration of reciprocity and continuous ‘tinkering’, ultimately answers the question ‘Cui bono?’ by primarily ben-

Care-based issues have been integrated into an inclusive and participative approach.

Technical advance in ‘caring societies’

We are currently experiencing multiples crisis of care. Emerging from the artificial demarcation of production *and* reproduction in capitalistic economies, various forms of care crisis of care have been recognized and described up to the present day. Meanwhile, the crisis of care is pervasive socially, institutionally and globally with regard to the development of (recent) welfare systems, climate change and its impact on life on Earth. Given priority to economic control (Von Redecker 2020), principles of maintenance, repair, and sufficiency have been neglected or/and depreciated on a systemic level (Paulson 2017). As one answer, an ‘ethics of care’ (Tronto 1993) has been introduced and debated not only in social settings of care like child or elderly care, but also in all societal and cultural spheres of society. Hereby, technological development plays a crucial role in future visions of ‘caring societies’. In our article, we have shown that TA from the very beginning has emphasized a multitude of care-related aspects, such as the sensitive handling of technological advancements, the consideration of diverse social group interests, and the protection of ecological environment. As a result, care-based issues have been integrated into an inclusive and participative approach. However, based on our scientific projects in healthcare sector – which serve as a few examples – we have highlighted, that these efforts seem not enough to make a step forward towards ‘caring’ societies. Furthermore, the instances indicate that technological tools are not embedded into the social settings. There were visible tensions between the goals of technology development and the daily life accomplishes of these settings. Coming from the ‘ethics of care’ approach, we argue to develop a care-sensitive approach to technology development that values care, reciprocity, and continuous ‘tinkering’. Reciprocity in this context, refers to the idea that technology not only assists and enhances caregiving practices, but is also influenced and informed by the real-world needs and experiences of caregivers and care recipients. Furthermore, the integration of the ‘ethics of care’ into TA should ensure the ‘tinkering’ process following Mol (2008) and Mol et al. (2010). This ‘tinkering’ allows for continuous learning and adaptation of the technology

development within the dynamic context of care. This bidirectional influence ensures that technological solutions are not imposed upon care settings in a top-down manner but rather evolve through continuous feedback and adaptation, creating a more responsive and compassionate caregiving environment. By fostering this reciprocal relationship, the technology becomes an integral part of the care ecosystem where the values, needs, and well-being of all participants are given equal consideration and respect. However, as mentioned in the beginning, on the long term, the above described notion of care should be released from any anthropocentric position in order to create care relations which are not limited, neither by human-human relationships, nor by the embeddedness of humans in the cycles of nature.

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RESEARCH ARTICLE

Infrastructures of care: Ethics in everyday digital media use

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Abstract • This article conceptualizes digital media as infrastructures of care. Using care ethics, it explores the importance of maintenance and support for creating sustainable and equitable digital environments. Based on an examination of the challenges and user support relationships within digital media use, it proposes policy measures to enhance sustainability and inclusion, emphasizing the critical role of care in ensuring reliable digital infrastructures.

Infrastrukturen der Fürsorge: Ethik im täglichen Umgang mit digitalen Medien

Zusammenfassung • Der Artikel konzeptualisiert digitale Medien als ‚Infrastrukturen der Fürsorge‘. Anhand der Care-Ethik analysiert er die Bedeutung von Wartung und Unterstützung für die Schaffung nachhaltiger und gerechter digitaler Umgebungen. Auf der Grundlage einer Untersuchung der Herausforderungen und Unterstützungsbeziehungen, die mit der Nutzung digitaler Medien verbunden sind, werden politische Maßnahmen zur Förderung von Nachhaltigkeit und Inklusion empfohlen. Die zentrale Rolle der Fürsorge bei der Gewährleistung zuverlässiger digitaler Infrastrukturen wird dabei besonders hervorgehoben.

Keywords • media maintenance, repair, warm experts, environmental sustainability, social sustainability

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Introduction

This article conceptualizes digital media as *infrastructures of care*, focusing on practices of maintenance, upkeep, and customization in personal digital media environments. Drawing on empirical data, I illustrate how care is woven into human-technology interactions through both individual and collective acts of maintenance and support. This approach highlights often-invisible aspects of digital media use, such as disruptions, adaptations, and repairs, and their dependency on broader technological developments. Rethinking digital media use in this way reveals how strengthening social relationships and redefining priorities in political decision-making can shape a more inclusive and sustainable digital society.

Digital media, broadly defined to include all interconnected media technologies that facilitate communication, work, learning, and social interaction (Ytre-Arne 2023), play a fundamental role in the fabric of daily life. In this article, I propose understanding them as infrastructures, a concept that underscores their pervasive and essential role in everyday existence. Drawing on Star and Ruhleder’s (Star and Ruhleder 1996) framework of eight key characteristics of infrastructures, these can be applied to the digital media we regularly use. For instance, they are embedded in social structures and practices and learned as part of communities of practice, where social norms both shape and are shaped by the transmission of knowledge. One of the most notable characteristics of infrastructures is their often-invisible nature, which becomes apparent and prompts reflection only in moments of failure. This also applies to digital media, whose functioning we take for granted in everyday routines, often overlooking the crucial role that regular maintenance (Balbi and Leggero 2020) and updates play in ensuring their seamless operation.

Building on the understanding of digital media as infrastructures, this study employs the lens of care ethics to emphasize the crucial role of care practices. These practices are essential for maintaining technological functionality, for the management of which social relationships are sought and cultivated at the same time. Although largely underexplored in the context of digital media, these care practices merit deeper investigation and integration into policy-making, as they offer valuable insights

for achieving sustainability goals. Sustainability, defined in the Brundtland Report as the ability to meet present needs without compromising the future generations' capacity to meet theirs, is framed here within the 'three-pillar model', encompassing environmental, social, and economic dimensions (Purvis et al. 2019). Although it is a widely debated concept, it has not been a central focus of communication studies to date, with the notable exceptions of research on climate change reporting and, more recently, on the communication of climate activists and their use of networked media and digital platforms (e.g., Kannengießer 2022, pp. 19). Lately, the notion of digital sustainability (Sparviero and Ragnedda 2021), addressing the responsible use of technology to minimize ecological footprints and promote social justice, has gained prominence. This includes the socio-ecological impacts

practices. Building on Tronto's conception, this article further draws on perspectives that extend care to interactions with technological objects (Denis and Pontille 2015; Puig de la Bellacasa 2011). In her seminal work, María Puig de la Bellacasa posits that care practices towards technologies and things reflect how we incorporate non-human elements into our ethical and political thinking. By integrating care into our relationship with objects, we acknowledge a deeper connection and responsibility towards the material world, fostering sustainable technological practices. In this sense, care – understood as ongoing attention and maintenance – is inherently linked to sustainability, as it involves nurturing not only interpersonal relationships but also the technological and material systems that ensure the longevity and responsible use of technologies.

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of digital media, from production to use, particularly in response to the growing demands of data-intensive services and everyday applications powered by special algorithms and artificial intelligence (AI). My reflections on care in digital media use engage both environmental and social sustainability, offering pathways for strengthening these dimensions.

Care ethics in digital media use

This article adopts the theoretical framework of the ethics of care, a paradigm that has gained prominence across disciplines such as philosophy, feminist studies, psychology, theology, and education, highlighting the significance of caregiving relationships and practices (Gottschlich et al. 2022). Care ethics (Gilligan 2003) underscores the importance of interpersonal connections and the moral obligation to respond to the needs of others, with an emphasis on the context and relationships involved in ethical decision-making. Joan Tronto has expanded this discourse by framing care as a fundamental social and political practice, extending beyond private contexts. From a feminist-ethical perspective, Tronto (1993) views care as a communal responsibility, critiquing the gendered division of care work that often goes unrecognized both publicly and academically. In her influential book, "Moral Boundaries: A Political Argument for an Ethic of Care", she emphasizes care's central role in achieving a more just society by maintaining and repairing the world – including bodies, selves, and surroundings. Additionally, her work also reveals and challenges power structures embedded in care

The intersections between care and digital media use are complex, ranging from providing affective care at a distance, high-tech support, and robotic services for the elderly, to the facilitation of traditional care practices such as "emotional labour" (Hochschild 1983, p. 7) and organisational tasks through digital media (Lai 2023). Gibson et al. (2021, p. 557) rightly argue that "[c]aring with and through communication media is central to methods and modes of being in the world with others". These forms of care point to various domestic labours that, despite being essential, are often rendered invisible or taken for granted. Feminist perspectives recognize these media practices as gendered, marginalized, and repetitive yet critical for managing daily life. This article shifts focus to a less obvious but equally significant aspect of care: 'care as material tinkering' (Lindén and Lydahl 2021). Inspired by Tronto's work, this approach accentuates the engagement with the materiality of media technologies as an essential aspect of digital media use, as further elaborated below.

Media maintenance: practicing care for the material environment

Care, framed as a responsive concept, underlines the necessity of reacting to the immediate conditions of our environment (Russell and Vinsel 2018). Rather than adhering to abstract principles, care responds to the contextual demands of everyday life, acknowledging the vulnerability and constant change of things (Denis and Pontille 2015). When applied to digital media use, care involves engaging with the impermanence and incompleteness of media technologies, necessitating regular maintenance,

updates, and troubleshooting. Elsewhere, I have described this ongoing technical labour, which involves both hardware and software, as a crucial part of the domestication of media technologies (Peil 2024). This labour is particularly relevant in the early appropriation phase, but remains significant throughout the entire domestication process, especially for digital networked technologies due to their specific nature and economic context.

provide assistance. Since then, numerous studies have focused on support relationships, either highlighting digital media's material nature as maintenance-intensive (Kennedy et al. 2015) or users' need for assistance, especially among the less proficient. Notably, many studies focus on older users, often conceptualizing them as uniform recipients of family support, yet findings indicate a diverse and varied reality; older users comprise multi-

Rather than adhering to abstract principles, care responds to the contextual demands of everyday life.

Maintenance practices are essential forms of care because they recognize the wear and vitality of matter, treating vulnerability as a natural state rather than a deviation from the norm (Denis and Pontille 2015). As Russell and Vinsel (2018) aptly put it, “maintenance is caring” (p. 259). In this regard, maintenance acknowledges that the function and reliability of media technologies as everyday infrastructures are continuously ensured through attentive care practices. Such practices require constant vigilance and adaptation, given the unpredictability of malfunctions, glitches, or technical disruptions. Thus, understanding maintenance as a form of care highlights the importance of these often-invisible activities in sustaining the daily functionality and reliability of digital media technologies, stressing the need for continual engagement and adaptation. This form of care also contributes to environmental sustainability by extending the lifespan of devices, reducing the need for frequent replacements, and fostering a more mindful, reflective relationship with technology.

Caring relations in media maintenance

A key aspect of contemporary media maintenance is the ongoing advancements in our digital environment. The rapid evolution of networked technologies such as smartphones and automated home devices, coupled with the myriads of individual configurations and potential error sources, have significantly made media usage more complex and sometimes challenging. This is further compounded by the economic imperatives of media environments, which prioritize profit over long-term-usability or simplicity, steering users towards continuous engagement and product dependency through frequent, but not always beneficial, updates and offerings. The increasing complexity and commercial pressures of these technologies can overwhelm users, making media maintenance more challenging. When individual media maintenance is neglected or becomes unfeasible, disruptions in usage occur, requiring assistance. Such support may come formally through service offerings and helplines, or informally within social networks. Two decades ago, when the internet was still new, Maria Bakardjieva (2005) introduced the concept of ‘warm experts’ to describe individuals within one’s close social circle who possess relatively higher knowledge of the internet and

ple generations with distinct digital media experiences and skills (Hunsaker et al. 2019; Olsson and Viscovi 2018). This indicates that media maintenance, as a form of care, encompasses all individuals and extends beyond individual concerns as it involves collective problem-solving initiatives. Care practices in this context manifest at two levels: in the maintenance of technology’s materiality and functionality and in the activation of interpersonal relationships towards a shared goal. This dual expression of care aligns with two pillars of sustainability as outlined in the three-pillar model (Purvis et al. 2019): First, environmental sustainability is fostered through attention to the material conditions of technology, including adaptation and customization, which likely extend the lifespan of devices and strengthen attachment, potentially reducing the frequency of replacements. Second, social sustainability is advanced by enhancing access, building digital competencies, and cultivating communal support networks to navigate the complexities of digital technologies.

Fieldwork

Data and methods

This study is grounded in a comprehensive corpus of qualitative data collected between 2017 and 2022, employing a multi-method approach to examine media maintenance practices and support relations. Derived from the theoretical exploration of media technologies as *infrastructures of care*, the research inquiries include

- a) identifying types of media maintenance tasks,
- b) exploring strategies employed to resolve issues, and
- c) examining the social relationships mobilized to address related challenges.

Participants were predominantly students of media and communication studies from Austrian and Southern German universities, selected via convenience sampling. All provided informed consent to ensure anonymity and confidentiality. The analysis focuses on five datasets (Tab. 1). The data sets were selected primarily for illustrative purposes and analyzed using qualitative con-

Sets	Study details
Set 1	Written Narratives (2022): Responses from eight undergraduate students at an Austrian university detailing their frustration experiences with media and related maintenance practices, articulated in a structured format based on specific prompts.
Set 2	Collective Diary (2022): Entries from 13 undergraduate students at an Austrian university documenting instances of media-related challenges over a semester on a GDPR-compliant platform, offering insights into everyday user experiences and support mechanisms.
Set 3	Support Network Diagrams (2019): Visual representations by nine graduate students at an Austrian university, illustrating the interpersonal networks involved in troubleshooting digital media issues, and highlighting the social dimensions of technological interactions.
Set 4	Written Responses (2017-18): Detailed accounts from 20 undergraduate students, providing a narrative of their encounters with media technology-induced frustrations and related maintenance activities.
Set 5	Written Responses (2018): Insights from seven students from a university in Southern Germany, focusing on their challenges and frustrations with digital media technologies and related maintenance activities.

Tab. 1 Overview of sample. Source: author's own compilation

tent analysis (Mayring 2014) with MAXQDA software, focusing on key dimensions such as identified problems, solution strategies, error phenomena, and consequences of errors. To ensure confidentiality, all personal identifiers have been anonymized.

A vulnerable infrastructure of everyday life

The data analysis shows that disruptions in digital media use are common, highlighting their role as intrinsic elements of digital infrastructures. All participants easily documented incidents where digital media became conspicuously visible during malfunctions, shifting from their usual state of transparency to a prominent disruptor, compelling users to confront the underlying technological logics, idiosyncrasies, and flaws. One participant, a graphic designer, described a personal experience with technology: “Having used Macintosh computers since I was fifteen, I was initially surprised at how little most of my trained colleagues knew about the technology they used daily. This ignorance eventually transferred to me, and I often only realized my lack of understanding when problems arose, forcing me to confront the complexities behind the interface. The error messages prompted me to engage with the technology, though not all interactions led to increased understanding.” This excerpt from a narrative highlights that digital devices are designed to interface with users primarily as consumers, not as informed operators, and only during breakdowns are users driven to engage with the technology on a more technical level.

Further complicating the user experience is the ‘perpetual beta’ state of digital infrastructures, characterized by relentless upgrades and a production logic geared towards constant change and improvement. This results in a digital landscape where errors are common, arising not only from user mistakes or insufficient skills but from an infrastructure inherently susceptible to various faults. The documented errors shed light on significant issues that were grouped into five main categories: unexpected application failures, mandatory software updates, connectivity issues, compatibility problems, and hacking vulnerabilities. These categories underscore both the unpredictable and often frustrating experience of digital media users and the intrinsic vulnerabilities of the underlying infrastructures. The highly individualized nature of errors, manifesting differently across devices, complicates troubleshooting efforts, as evidenced by participants

frequently finding that online solutions fail to align with their specific problems. “When I encounter problems, whose causes are unclear, I seek online solutions. However, these are often unhelpful because the described issues do not match my situation exactly or address different devices”, remarked a participant. This specificity highlights the challenge of deriving generalizable knowledge from personal repair experiences and underscores the need for more tailored support mechanisms.

While technological disruptions are often initially perceived as trivial, the implications, as documented by participants, indicate a profound impact on daily functioning. These incidents not only illustrate the inconvenience of digital dependency but also highlight critical obstacles to unrestricted communication and access. Such experiences have led to an acute awareness among users of their reliance on digital infrastructures, which, when disrupted, render them inactive and unable to perform necessary tasks or access essential services. One participant expressed frustration with social media and online systems, noting the passive wait for software fixes, in contrast to hardware issues that can be temporarily resolved by resetting devices. The critical tension between user autonomy and the opaque operations of digital infrastructures draws attention to how visible breakdowns not only disrupt daily activities but also reveal the constraints of user control, as well as the far-reaching influence of these technologies on everyday life.

Maintaining infrastructure as a collective concern

This analysis continues to explore the nuanced dimensions of media maintenance as a collective responsibility, where technical upkeep and troubleshooting intersect with care ethics to shape digital media experiences. As digital systems and platforms expose the limitations of user control over technology, participants’ narratives reveal a layered strategy when confronting technological failures. Initially, they usually engage in trial and error, reflecting a hands-on interaction with digital interfaces – restarting devices, logging out and back in, or refreshing applications. When these efforts falter, they resort to online searches for solutions. As challenges persist, the recourse to ‘warm experts’ becomes inevitable. This escalation from personal attempts to community-based assistance underscores the inherent social nature of media maintenance.

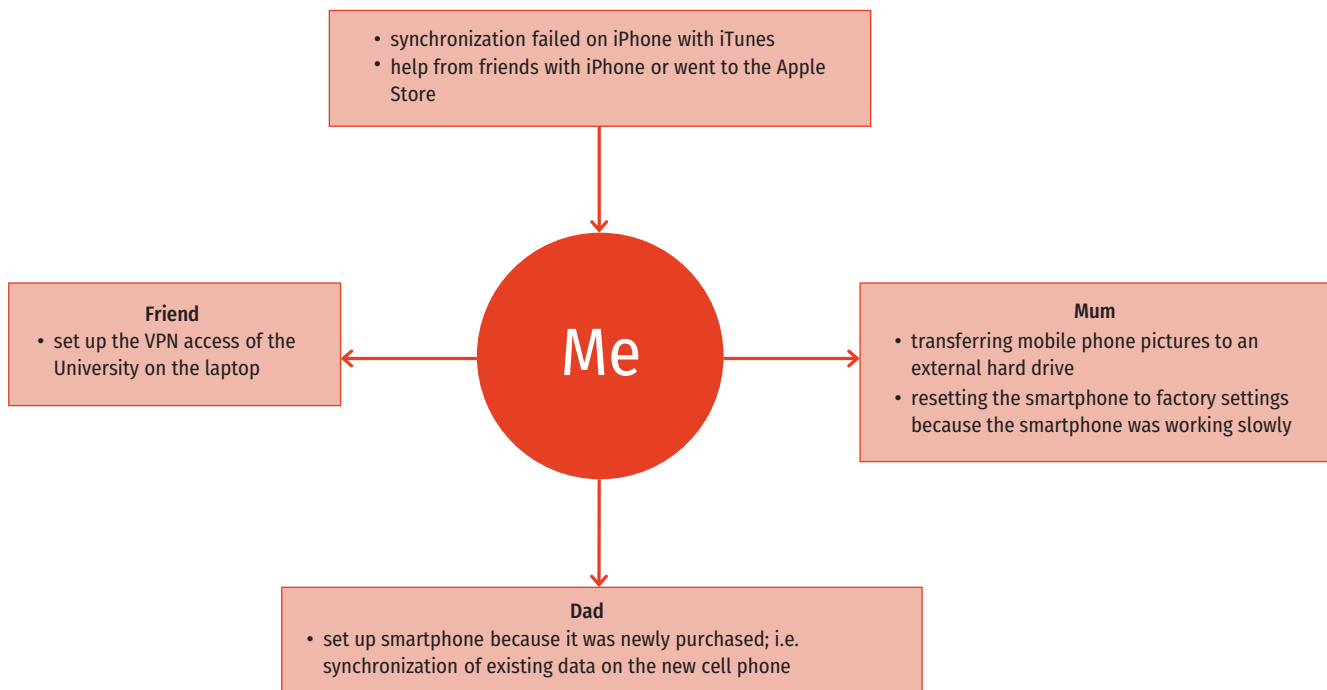


Fig. 1 Participant's support network diagram. Source: author's translation and compilation based on original by study participant

Support within digital technology use not only unfolds as a multifaceted social interaction, transcending skill level or age distinctions, but also reveals the unique character of problems encountered in digital media usage. Issues go beyond simple error correction; applications often remain inaccessible due to required settings adjustments or the initial setup of new devices. These challenges once again underline the individualized nature of engaging with digital technologies – processes that may not necessarily simplify with prior experience. As showcased in the support network diagrams (Fig. 1), the dynamic exchanges within these networks demonstrate a bidirectional flow of assistance, where individuals both give and receive support depending on the issue at hand. This illustrates the communal aspect of navigating digital complexities and emphasizes the importance of blending technical know-how with adaptive social strategies.

One participant noted the emotional and relational nuances of receiving support: “After being completely overwhelmed, I asked my mother for help, and she solved the problem with a few clicks in a few minutes. I felt both more upset and relieved afterward.” This account delineates the complex emotional terrain navigated in technological care, where relief at resolving an issue coexists with frustration over one's dependency. Interactions like this demonstrate the dual role of technological care: addressing immediate issues while fostering emotional support and relational ties. An illustrative example of another participant deepens this understanding: “My mother called me in desperation today because she couldn't access her email on the PC. She had no idea how to reset her password. I guided her, and after about 40 minutes, we managed to get her back into her email.” This scenario

highlights how care practices frequently emerge in moments of desperation, transforming the resolution of a technical issue into an opportunity for interpersonal interaction and support. The nurturing of these social bonds through technological assistance reveals a deeper layer of care that transcends mere technical help, extending into emotional and social support realms.

Discussion and conclusion

This article has examined some key aspects of digital media use that reinforce their role as infrastructures of care and situate media maintenance within the ethics of care. It demonstrates that all users, regardless of their expertise, are continuously confronted with the challenge of engaging with the materiality of ever-evolving digital media technologies. Engaging with media technologies often requires them to initiate, configure and occasionally repair digital systems to take advantage of their benefits. Recognizing the transient and vulnerable nature of technological artefacts fosters a politics of knowledge that focuses on the care and preservation of materials, illuminating the labour underpinning the creation of socio-material orders.

The maintenance and care of digital media, as outlined, extend beyond individual efforts, and underline the collective commitment needed to effectively manage these infrastructures. These activities demand political and institutional support to strengthen the informal care networks that are vital for inclusive and effective digital media use, thereby enhancing social sustainability. Establishing technology support centres and fostering warm

expert relations through community-based programs would be valuable steps, improving accessibility and user proficiency while formalizing the integration of community-based care practices into digital media usage. Particularly, in addressing skill disparities, this form of care helps to narrow the digital literacy gap, a crucial element that should be emphasized in policy measures aimed at creating a more socially sustainable digital society. While this commendable form of care is valuable, it should not obscure the technology sector's responsibility to reduce the overall need for technological care. Manufacturers must prioritize developing reliable, user-friendly technologies that enhance skills and understanding, rather than fostering greater dependency on digital products. The data from the present study,

economic considerations. Efforts to improve sustainability in the technology sector have tended to focus on the hardware level. Initiatives such as Austria's 'repair bonus', the European 'Right to Repair' legislation, and France's reparability index not only promote more sustainable consumer behaviours but also compel manufacturers to produce more maintainable products. While these are commendable steps in the right direction, this paper emphasizes the critical importance of also addressing the software dimensions of environmental sustainability. Frequent disruptions in digital processes, coupled with software incompatibilities or malfunctions, not only lead to substantial losses in time and productivity for users but also significantly increase data traffic, contributing to resource wastage through

The highly individualized nature of errors, manifesting differently across devices, complicates troubleshooting efforts, as evidenced by participants frequently finding that online solutions fail to align with their specific problems.

however, suggest a different outcome. Participants frequently reported feelings of powerlessness and lack of control when faced with technological breakdowns. As Bunz and Meikle (2018) argue, smart technologies often “de-skill[s] and disempower[s] the user” (p. 16) rather than offering empowering learning opportunities. Such user experiences, where poorly designed technologies reduce users to passive consumers or planned obsolescence disrupts digital practices, ultimately undermine competence and autonomy. Thus, the findings raise critical questions about the tangible limits of care activities. Socially sustainable care practices must therefore consider carefully how disruptions in media usage occur – whether due to skill gaps or flaws in digital services – and determine where assistance is needed, as well as how caring relations in digital media use contribute to the long-term development of user skills.

With respect to environmental sustainability, care practices involving the tinkering and maintenance of material technologies can similarly be viewed as a double-edged sword. On the one hand, such practices hold the potential to prolong device lifespan, thereby mitigating the environmental impact of production and disposal. On the other hand, the ability of individuals to undertake effective repair and customization is constrained by the structural limitations imposed by manufacturers. Thus, broader systemic change is required, including regulatory measures that mandate corporate responsibility for facilitating reparability and extending product life cycles. Recent policy developments indicate progress in this area, underscoring the need to integrate care ethics into technology policy frameworks. In doing so, the emphasis must shift towards sustainable technological infrastructures that balance social and environmental imperatives with

workarounds and data redundancies. These issues often stem from system failures, repetitive updates, and poorly designed software. Of particular concern is the vast data processing required by AI and algorithm-driven processes, which are increasingly integrated into everyday technologies, often unnecessarily and without user awareness. These integrations increase system complexity and introduce new errors while also relying heavily on data centres, many of which are still powered by fossil fuels, consume vast amounts of water, and depend on the extraction and refinement of raw materials necessary for data storage and processing (Taffel 2023). Addressing inefficiencies at the software level is therefore crucial for reducing greenhouse gas emissions and aligning with wider sustainability goals. By adopting strategic measures that target these challenges, the technology sector can foster a more equitable, sustainable, and resilient technological landscape that better serves the common good.

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RESEARCH ARTICLE

‘Daseinsvorsorge’ as a care-based principle of transformation: Perspective toward a caring development of sustainable cities

Benedict Lang^{*,1} 

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Abstract • Cities around the world are using smart city approaches to transform urban infrastructures toward sustainability. Critical academic studies of smart city projects often fail to integrate the aspect of care. Based on empirical evidence, I argue that *öffentliche Daseinsvorsorge* (public services provided to fulfil basic human needs) as a guiding principle of urban development can serve as a starting point for responsible research and innovation that considers questions of care. To do so, I first develop the concept of *Daseinsvorsorge*, which will serve as a critical lens to evaluate transformation projects from a perspective of care. Then I situate the concept in broader academic debates on responsible research and innovation (RRI) and technology assessment (TA). Furthermore, I propose *Daseinsvorsorge* as a concrete normative framework that reflects the role of municipal administrations and their responsibilities toward the citizens.

Daseinsvorsorge als fürsorgebasiertes Prinzip der Transformation: Perspektive für eine fürsorgliche Entwicklung nachhaltiger Städte

Zusammenfassung • Weltweit nutzen Städte Smart-City-Ansätze, um städtische Infrastrukturen in Richtung Nachhaltigkeit zu transformieren. Kritische wissenschaftliche Untersuchungen von Smart-City-Projekten lassen den Aspekt der Fürsorge bisweilen vermissen. Auf der Grundlage empirischer Erkenntnisse argumentiere ich, dass öffentliche Daseinsvorsorge als Grundprinzip der Stadtentwicklung einen Ausgangspunkt für verantwortungsvolle Forschung und Innovation bilden kann, die Fragen der Fürsorge berücksichtigt. Dafür konkretisiere ich zunächst das Konzept der Daseinsvorsorge, das als kritische Linse dienen soll,

um Transformationsprojekte aus einer Fürsorgeperspektive zu bewerten. Anschließend verorte ich das Konzept in Debatten über verantwortungsvolle Forschung und Innovation und Technikfolgenabschätzung. Darüber hinaus schlage ich Daseinsvorsorge als einen konkreten normativen Rahmen vor, der die Rolle der Stadtverwaltungen und ihre Verantwortungen gegenüber den Bürger*innen einbezieht.

Keywords • *Daseinsvorsorge, smart city, responsible research and innovation, care*

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Introduction

Globally, cities set ambitions carbon-neutrality and sustainability goals, driven by their crucial role in both causing and combating climate change and related challenges. The discourse on sustainable cities intertwines with digital transformations, with smart city development as a central strategy. Digital technologies, sensors, and data platforms aim to reduce emissions and enhance livability. Sustainability has gained prominence in smartification discussions, superseding associations with other global trends. It involves sensitive municipal areas and services, contextualized within the concept of ‘öffentliche Daseinsvorsorge’, which I will elaborate on later.

To support smartification and increase cities’ sustainability, the German government provides 820 million Euros funding to enable so-called *model projects*. Through so-called strategies – policy papers that lay out plans for the smartification – and their implementation, municipal actors shall pilot digital projects that can be circulated and scaled later.

Scholars have examined how smart city projects and the digitalization of the city impact modes of governance (Cardullo and Kitchin 2019; Clark 2020; Shelton et al. 2015). This article

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supports the argument that these reconfigurations of modes of governance are not determined by certain technologies per se but rather through how we design and implement them.

I argue for responsible implementation of digital projects for sustainable urban transformations. Responsibility in this context refers to the broader debate on how to not only critically assess but also include values in technology development (Dignum 2019; Liebert and Schmidt 2010). I propose the concept of öffentliche Daseinsvorsorge as one starting point for intersecting responsible research and innovation (RRI) with sustainable transformations and care.

Who defines care provision and why?

Acknowledging the significance of care-taking activities reveals hidden power relations and dynamics underlying infrastructures and services that sustain communities. Care, in this sense, draws attention to its relevance for the wider economy and society's maintenance (Gottschlich et al. 2014, p. 10). In the article, I first introduce the concept of öffentliche Daseinsvorsorge. Second, make concept to make applicable to transformation projects. Third, I depict exemplary how this application could look like. Finally, I draw connections to RRI, technology assessment (TA) and care.

Daseinsvorsorge in the German smart city discourse

Öffentliche Daseinsvorsorge literally translates into 'public provision for being' and represents a specific understanding of public service within Germany. It is both a legal term and a guiding principle within municipal administrations. Social scientists have studied its meaning from different perspectives (Neu 2009). Generally, it describes the responsibility of the state or municipality to provide services that citizens depend on to sustain themselves. The extent of these services remains contested (Mause 2018).

Originally, the concept was developed by Ernst Forsthoff in the 1930s, who studied the implications of industrialization for citizens. His core argument: citizens who are moving to cities for industry workplaces, lose their ability to sustain themselves due to the reduced available space they have. The provision of services for sustaining citizens becomes the mandate and the legitimization for administrative power. Instead of protecting the citizens against perils from the outside – which is the legitimization for governmental power with Hobbes – the state is taking care for the citizens within its borders. As the local government is taking care of their citizens in certain ways, it gains respect, and legitimization through these services (Forsthoff 1938).

Today, Daseinsvorsorge serves as principle for municipalities. In Munich, for example, the city is hosting a 'Day of Daseinsvor-

sorge' every year on their central square, where different actors from waste management to different departments of the administration present themselves and their services and try to get in touch with citizens. This shows the depth of its engraving into the municipalities self-understanding and identity. The term is also a political device for those demanding a strong state in the light of increasing economic divides.

There are discussions about translating Daseinsvorsorge into the realm of the digital, consisting mainly of two strands: first, whether access to digital services like the internet should be considered a part of the provided services (Meier et al. 2024;

Papenfuß et al. 2022). Second, how already provided services can be offered more efficient, leveraging the potential of digital tools.

The latter is one core idea of the funding scheme 'Modellprojekte Smart Cities'. Even though Daseinsvorsorge is not significant in the policy papers like the Smart City Charta, the publication 'Digital Daseinsvorsorge for resilient municipalities' centers it, describing how digitalization can be used to foster Daseinsvorsorge. This underscores the general prevalence of the concept in the urban context. Still, in the concrete municipalities, whose smartification endeavors I observed in empirical research, the concept did not play an important role in the actual smart city projects. It is neither mentioned prominently in the digitalization strategy documents, nor was it explicitly centered in workshops and discussions, I observed in different municipalities.

Making Daseinsvorsorge applicable as a careful lens

Therefore, I propose to strengthen it as a concrete principle of care. The debates on the importance and nature of care in STS (Lindén and Lydahl 2021) and beyond involve various notions, including labor and emotional investment in care and the study of relations of human and non-human actors to uncover sustaining activities (Mol 2008; Puig de la Bellacasa 2017). Care activities require explicit observation and description: who cares for whom and why? Who defines care provision and why? Tronto has established connections between moral values and the political realm through her proposed ethics of care. Care is not only an important human activity but also points towards power dynamics and societal injustices if we look at the amount of care that is provided by whom (Tronto 2020).

Daseinsvorsorge or the term Sorge literally translates into care, creating a strong connection. The introduction of the concept suggests that as a legitimization for its power the municipality has a responsibility to take care of citizens through the provision of services.

In the sustainable transformation project,	For these four different questions, Daseinsvorsorge provides the following answers:
...how do we envision the relationship between the citizens and the state?	The citizens are dependent on the state to cater to their basic needs as they cannot sustain themselves, the state has a responsibility to take care of the citizens.
...what is our understanding of the role of the state?	The state engages with the citizens and has an important and strong role.
...how does the state and the administration legitimize itself and its doing?	The power of the state is legitimized through the care it provides for the citizens. The goal of municipal administration therefore needs to be to fulfil their responsibility for care to be trusted and accepted.
...how are citizens participating (taking part) in the city?	All citizens need to be able to take part in everyday life in the city. Originally, participation is foremost meant in an economic and material sense. This includes access to water, public space, electricity or other services necessary for being. Today, other spheres like political influence are discussed under this term as well.

Table 1 Dimensions of Daseinsvorsorge. Source: author's own compilation

To make Daseinsvorsorge applicable as a care-focused framework for concrete transformation projects I break it down to concrete normative and qualitative questions. Based on the introduction of the concept by Forsthoff, I initially suggest four dimensions (table 1) that focus on the relationship between citizens and the state in reflection of relationships of those who give and receive care. However, the framework could be extended or altered to reflect local contexts.

A lot of actors provide so-called solutions to support cities' sustainability endeavors. Smart irrigation as a concrete example for such offers by different startups who want to enter the cities. The project aims to increase efficiency in irrigation. Instead of fixed routes for watering plants and trees, different sensors collect humidity of soil and plants. Algorithmic procedures are performed in central data platforms to determine the plant's health and to evidently suggest when to water plants. The digital solution contributes to sustainability by saving water and improving trees health as they are vital for cool city despite rising temperatures.

Using the four dimensions defined above, we can normatively assess the proposed transformation. The following description is no empirical observation but rather speculation to exemplify the potential of the suggested approach. In practice, such an evaluation or analysis could be performed before the implementation phase together with key stakeholders in workshops and discussions not only for pro/contra decisions but also to be aware of implicit reconfigurations introduced by the project their potential remedies.

At first, the relationship between citizens and the state is not affected by altered internal procedures for a specific service. We can, however, speculate about alternative relationships that could be imagined for taking care of plants and trees. Citizens could – for example – be integrated more directly as patrons for plants, leading to bigger shifts in the relationship between citizens and state. While in this concrete example, the relationship might not be of utmost importance for citizens' ability to sustain themselves. Still, the overall relation between citizens and state is composed of a huge number of small interactions that add up to each other.

However, the relationship between citizens and the state is still altered through the introduction of private actors that provide the technologies for the project. Initially, this is transparent to the

citizen, with the state delegating certain decisions to a software-platform. Looking closer, when bringing in new actors, they also bring their own interests. With more actors and interests at the table, citizens' interests become one next to others mediated by the government. While questions about privatization are not new to smartification projects, they remain important to be reflected.

Looking at the concrete project, the state redefines its role from only providing the specific service to providing the specific service efficiently. Therefore, it reacts to increased pressure on resources like water or workforce. Also, the state acknowledges deficits of the administration's operations, suggesting a knowledge-deficit in the maintenance of plants. To cope with this deficit, the municipalities bring in external actors and redraw boundaries of their responsibilities and capabilities. Doing so, they confirm and support the role of the state as the non-efficient state. Efficiency is not new to smart cities but has been discussed in municipalities before. However, this reflection illustrates that the particular smart city project is contributing discursively to narratives of efficiency, strengthening its importance.

Legitimization: Through acknowledging the information-deficit in regard to the plants' health the administration is also extending its own legitimacy. It is not sufficient to just take care of the urban space based on existing expertise and knowledge, but the care-taking also needs to happen efficiently. While the general legitimization for exerting power over space and citizens remains the same, it gets extended.

Participation: Ernst Forsthoff (1938) introduces Daseinsvorsorge as a reaction to the reduction of so-called controlled space. To sustain themselves, the citizens are dependent on the government to govern shared spaces in their interest. The tree project is making public spaces more accessible as trees are absorbing CO₂ and providing shade, leading to cooler temperatures. Therefore, the project fosters participation in the material sense of Daseinsvorsorge, as it increases the citizens possibilities to be a part of the city.

Overall, the discussion is not supposed to provide a yes or no decision about whether to implement the project. Rather, it surfaces potential reconfigurations in urban governance, that need explicit consideration like for example efficiency narratives or privatization. The aim is to show that by applying the different dimensions of Daseinsvorsorge, we can be sensitive about the (un)intended impact on relationships of care between citizens

and the state. How do we position ourselves towards these effects and do we want to accept, circumvent or alter them?

It is important to mention, that what I have demonstrated above is merely the application of the Daseinsvorsorge perspective on a project description or project proposal. It deals with assumptions and speculations about the project based on its description. When it comes to actual implementation, empirical evidence suggests hurdles for the projects (Hollands 2008; Cole et al. 2023). This is why the evaluation must exceed the planning phase and be an iterative process.

Daseinsvorsorge and responsible research innovation

While the chapter above has shown how the concept of öffentliche Daseinsvorsorge can be used as a critical lens and a reflective tool, the following part will connect it to debates on responsible research and innovation and technology assessment. I propose to use it as a starting point for careful transformations in urban contexts.

and Schmidt 2010). In RRI Responsibility serves as a guiding principle. Who is responsible for what against whom and why? RRI needs to be situated in local and concrete circumstances to answer these questions. It is against this theoretical and conceptual backdrop that I present reasons why Daseinsvorsorge should be a central aspect of RRI in the context of sustainable urban transformations.

First, the values and concepts that shall be considered in RRI need to be related to the domain, the technologies are developed in. Familiarity makes it easier for the actors to use and apply the concept and its underlying normative perspectives. Within the context of municipal administrations in Germany, the term Daseinsvorsorge is widely spread and embedded and is therefore ideal for implementing a concrete understanding of responsibility.

Second, it is necessary to build on values or concepts that take a clear normative stand. Debates in TA and STS have contested the notion of neutral technologies where only the application decides about its impact. Also, technology is not inherently good or bad but it rather depends on its implementation and integration into its context. Instead of alleged neutrality, reflexivity

*There is a shared understanding of Daseinsvorsorge across cities,
each city can still have their own focus and interpretation
how they want to enact it locally.*

Based on the definition of the European Commission “Responsible Research and Innovation (RRI) implies that societal actors [...] work together during the whole research and innovation process to better align the process as well as its outcomes with the values, needs and expectations of society.” (European Commission 2014). While this definition is broadly acknowledged, “it is at least curious that there is hardly any reflection in the RRI literature on what values actually are” (Boenink and Kudina 2020, p. 451). I am accepting that conceptual vagueness and use values in the sense of abstract principles or ideas that exist and are contested within (local) communities that guide valuing-processes regarding (un)desired impact of technologies.

Explicit links between RRI and care can be found for example with Stilgoe et al. who claim that “responsible innovation means taking care of the future through collective stewardship of science and innovation in the present” (2013, p. 1570); or with Owen et al. who define care as one of two dimensions of RRI in the sense of explicitly making decisions about what (not) to do in science and innovation (2013, p. 36).

In 2014, a conference was held to explore the connections between these RRI and technology assessment (TA) (Gudowsky et al. 2014) which can be seen as neighboring fields (Scherz et al. 2020). TA has been developed from a mere assessment and technology development, for example in prospective TA (Liebert

and transparency shall address that there will always be some normative standpoint in TA (Torgersen 2018) and RRI. Terms like responsibility (Gudowsky et al. 2014) and fairness often remain vague. As concrete norms are necessary for application, Daseinsvorsorge carries normative positions regarding the four dimensions described above.

Third, while there is a shared understanding of Daseinsvorsorge across cities, each city can still have their own focus and interpretation how they want to enact it locally. Translating the norms to the local context is important for the acceptance in the respective city. Daseinsvorsorge allows for this translation, providing outlines that can be filled with local specifics.

Fourth, the sustainable transformations are at first run by the state. Municipalities are facing different expectations how they are supposed to innovate in comparison to for example startups. Being a governmental body raises the standards in relation to security, stability and inclusivity. As municipality, you can not only focus on one specific client or target group but rather have to provide services for all citizens which requires to reflect barriers and accessibility. Also, the data that is handled, is often sensitive and requires additional measures of protection. Therefore, it is necessary to build on concepts explicitly addressing the state as an agent. Daseinsvorsorge fulfils that by arguing that the state needs to care for its citizens.

Finally, *Daseinsvorsorge* shares a literal connection with responsibility: Forsthoff not only introduces the concept of *Daseinsvorsorge* but also introduces the idea of so-called *Daseinsverantwortung* – the responsibility for the being that allocates the obligation to make sure that the citizens are able to be with the state. While the state cannot take care of every citizen individually, the responsibility is to be fulfilled by providing services that the citizens themselves can rely on.

Picking up the definition of RRI again, this article argues for a specific responsibility of the municipal administration to reflect questions of öffentliche *Daseinsvorsorge* “during the whole [...] innovation process” (European Commission 2014). When transforming urban spaces, citizens’ needs and perspectives about what constitutes their being should be the top priorities.

To be more specific, this could be implemented for example through a clear examination of projects before they are implemented. Like in the evaluation of smart irrigation, provided before, projects could be evaluated using a *Daseinsvorsorge* canvas. Not to make yes or no decisions but rather to see how specific decisions about the project’s implementation affect the citizens in relation to *Daseinsvorsorge*.

Implementing such strategies needs to reflect different perspectives and legal boundaries of the city administration, the state, and national governments. These processes need to be iterative, reflexive and inclusive, acknowledging that there will be no off-the-shelf method that can be reused everywhere and for any sustainability transformation.

Conclusion

This article illustrates how *Daseinsvorsorge* integrates care into urban transformation, providing a reflective framework for RRI. I have depicted how four dimensions make the concept applicable as critical lens to evaluate concrete projects. I have exemplified this evaluation, illustrating the potential of the approach.

Connecting *Daseinsvorsorge* as a principle of care to debates on RRI and TA contextualizes this approach. Taking the proposed approach further, the integration of *Daseinsvorsorge* in specific projects of sustainable transformation needs to be made more concrete in terms of existing experiences with RRI. To do so, I suggest conducting research projects in which actors from municipalities and social sciences or STS collaborate on projects with the aim of ensuring that the municipalities keep *taking care* of their citizens in transformation projects.

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