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Beyond social acceptance in wicked problems: A socio-ethical assessment framework for technology governance

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ABSTRACT

Introducing emerging technologies is often seen as successful when social acceptance has been achieved. In the case of 'wicked' problems, social acceptance might be an insufficient quality criterion for the desirability of technological developments, because the focus on social acceptance can risk overlooking crucial ethical considerations. As such, this paper addresses the research question of whether technology governance frameworks can go beyond mere social acceptance issues and incorporate ethical considerations. By exploring three projects in which potable water reuse has been introduced, we have identified the limitations of common governance approaches to enhance social acceptance, including common participation and 'Opening Up' participation strategies. Our explorative study indicates that even an ideal participation strategy is insufficient to ensure ethical acceptability due to the lack of critical reflection on the problem this technology development is solving. If a given problem is too narrowly defined to artificially favor one solution over another, the exploration of alternative solutions will be hindered, potentially reinforcing unsustainable practices. To extend on existing approaches to participation, we propose a socio-ethical assessment framework that integrates social acceptance measures with ethical acceptability considerations to address these shortcomings. This framework emphasizes the importance of ethical participation, including the representation of marginalized voices, future generations, and non-human entities. It also urges to critically examine the framing of the problem itself, acknowledging the wicked nature of issues like water scarcity. By doing so, technology governance can become more responsible by aligning societal and ethical considerations.

1. Introduction

Problems can be seen as 'wicked' if there is no consensus about the problem definition and the appropriate solution (Rittel & Webber, 1973), and solutions are prone to raising controversy. For instance, in the wicked problem of water scarcity (Quentin Grafton, 2017; Sanya, 2020), the introduction of biotechnology or water recycling has met with public resistance. This resistance is typically framed as a barrier to project development and further technological innovation, where technology developers appear to believe that social acceptance is achieved if the public can be convinced to abstain from such resistance (Van de Poel, 2016).

As a case in point, opposition to direct potable water reuse is usually represented as a lack of knowledge by the general public, which is believed to be solved by better informing the public or by having pilot projects that enable members of society to learn about the benefits of the technology (Moesker et al., 2024b). However, by seeing learning as an activity that only comes from the side of the public, this framing reduces

the public to passive recipients of technology rather than recognizing them as active participants in a co-evolutionary process (Stirling, 2008). Numerous scholars have argued that genuine public participation enhances decision-making, increases legitimacy, and enables the development of more socially desirable technologies (Fiorino, 1990; Harris-Lovett, Binz, Sedlak, Kiparsky & Truffer, 2015; Wynne, 2006). As such, social participation can (and perhaps should) be seen as a *method* that allows for developing acceptable and more desirable technologies.

Nevertheless, achieving social acceptance through participation processes does not necessarily lead to the creation of more desirable technologies. An approach that exclusively relies on the input of participants invited to speak out on the desirability of technology development might foster problems such as bias, myopia, and groupthink (Solomon, 2006; Wynne, 2007; Young, 2016). Moreover, the question as to whether a technology can be regarded as desirable is intrinsically normative and as such, we believe that attending to the social acceptance concerns alone is insufficient for responsible technology governance, especially in the case of wicked problems characterized by

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complexity, conflicting values, and a lack of definitive solutions (Quentin Grafton, 2017; Rittel & Webber, 1973).

This paper argues that a more comprehensive assessment of the desirability of technology requires integrating ethical considerations alongside social acceptance. As such, the research question that is studied in this paper is whether technology governance frameworks can go beyond mere social acceptance issues and incorporate ethical considerations. To address this question, we will look at the controversial technological advance of potable water reuse, a technological system increasingly proposed to address escalating water scarcity (see, e.g., Gerrity, Pecson, Trussell & Trussell, 2013; Leverenz, Tchobanoglous & Asano, 2011). Despite its potential, potable water reuse faces significant social acceptance hurdles rooted in various context-specific concerns regarding, among others, safety, trust and the ‘yuck factor’ (López-Ruiz, Moya-Fernández, García-Rubio & González-Gómez, 2021; Ormerod & Scott, 2013; Scruggs, Pratesi & Fleck, 2020). With three currently ongoing potable water reuse projects in Phoenix, Scottsdale, and San Diego, serving as illustrative cases, this paper identifies the shortcomings of existing public participation practices and demonstrates how a ‘socio-ethical framework’ can provide new insights into the desirability of this technology.

This paper has the following novel aspects. First, we will show the importance of taking ethical considerations into account in matters of technology governance, and second, we will propose a socio-ethical assessment framework as a more robust alternative to enhance the quality of participation strategies. To do so, the paper will have the following structure. Section 2 introduces the socio-ethical assessment framework, which provides the conceptual foundation and overarching narrative for our analysis. Section 3 provides essential background information on potable water reuse technology and the three case studies in the U.S. cities of Phoenix, Scottsdale, and San Diego. Section 4 examines existing approaches to social acceptance in these projects, highlighting their limitations. Section 5 then explores the ethical dimensions of potable water reuse and introduces the concept of ethical acceptability. Finally, Section 6 presents our conclusions and discusses the implications of our findings for responsible innovation and governance in water management.

2. A framework for socio-ethical assessment

Building upon the limitations of solely pursuing social acceptance, as outlined in the introduction, this section introduces the theoretical considerations that allow us to develop the socio-ethical assessment framework. This framework offers a more comprehensive approach to evaluating and guiding the governance of new technologies by integrating both social acceptance and ethical acceptability considerations.

This framework is connected to the findings from the literature on technology development from innovation theory (Garud & Rappa, 1994;

Nelson & Winter, 1977) and science and technology studies (Bijker, 1997; Rip, 1995) that counter the dominant approach to technology development in which technologies are fully developed before they are implemented in society. This ‘linear’ model of technology development fails to acknowledge that technologies will evolve further with the existing sociotechnical contexts in which they are implemented. New social practices and interdependencies will emerge after the societal introduction of a technology, which implies that the development of a technology is best seen as an ongoing process in which the input of users and affected parties is used to further advance the technology (Owen, Macnaghten & Stilgoe, 2012; Te Kulve & Rip, 2011). The socio-ethical assessment framework can be seen as an approach that allows for improving the quality of that input. The structure of this paper follows the framework outlined in Table 1, with the arrows representing the flow of our analysis.

We start by critically examining the social acceptance component, focusing on *common public participation* processes used in potable water reuse projects. Despite the diverse range of approaches to social acceptance (Moesker, Pesch & Doorn, 2024a; Wüstenhagen, Wolsink & Büerer, 2007), our analysis highlights a critical weakness prevalent in these practices: the frequent failure to capture a holistic set of socially relevant concerns.

To address this weakness, many potable water reuse scholars suggest *Opening Up participation* strategies, drawing upon Stirling’s (Stirling, 2008) concept of ‘Opening Up,’ expanding decision-making processes to include a broader range of perspectives (e.g., Binz, Harris-Lovett, Kiparsky, Sedlak & Truffer, 2016; Harris-Lovett et al., 2015; Katz & Tennyson, 2015). Opening up pertains to accounting for a wider variety of norms, values, beliefs and knowledge claims, for instance, by deploying participatory forms of decision-making in which societal members are invited to articulate their views and considerations (also see Ruiten et al., 2023). By including a wider range of perspectives, the decision-making process becomes enriched, leading to more robust outcomes. However, Opening Up participation can be undermined by manipulative practices, such as inducing an overly optimistic bias towards the technology and a strategic problem framing that narrows the public debate to discussing an acute symptom rather than the underlying systemic problem of water scarcity itself.

We propose incorporating *ethical participation* as a complementary lens to mitigate these shortcomings, focusing on the moral desirability of the participation strategies themselves. This includes considering the impacts on entities beyond the immediate stakeholders, such as future generations and non-human entities, who are often excluded from common participation processes. However, even ethical participation can lead to undesirable technology implementation because the problem space itself can be too narrowly pre-defined by decision-makers to favor a particular technological solution. A caveat here is that wicked problems typically bring about ‘normative uncertainties’ (Taebi, Kwakkel &

Table 1
Socio-ethical assessment – Connecting social acceptance and ethical acceptability.

	Procedural		Substantive
Social Acceptance	Common participation: Aims to address expected social concerns/implementation challenges.	→	Opening Up participation: Aims to identify overlooked yet socially relevant concerns.
		↙	
Ethical Acceptability	Ethical participation: Aims to ensure the moral desirability of the public participation process.	→	Opening Up the problem space: Aims to identify additional morally relevant concerns.

Kermisch, 2020), questions about which no decisive normative answers can be given. Conventional ethical theories, such as utilitarianism and deontology, are ill-suited to deal with such uncertainties, as these are based on moral norms and outcomes that are fixed (Hofbauer, 2023). It is precisely the quality of wicked problems that we do not know which norms and outcomes will become pertinent (cf. Van de Poel & Taebi, 2022). This shortcoming of conventional ethical theories implies that we have to introduce an alternative approach to ethics, which we will do below.

Following up on this point, we introduce a last assessment aspect to overcome a problem space that is too narrowly defined, which is *Opening Up the problem space*. The relevance of this aspect is essential in technological solutions to 'wicked problems' (cf. Rittel & Webber, 1973), where there is no agreement on the epistemic and normative nature of the problem. As such, any technology-based solution will raise objections about its feasibility and desirability. While authors working with the notion of social acceptance rely on social research methods to find out what people consider to be desirable, authors who focus on ethical acceptability have approaches from moral philosophy as their point of departure. As such, this aspect explores the problem of water scarcity more deeply by addressing alternative framings and proposed solutions. It also highlights the implications of a problem space that is too narrow on the desirability of technology development and the role public participation can play in shaping more responsible governance. With these concerns at hand, we urge technology implementation projects to move beyond a narrow focus on social acceptance towards a more holistic socio-ethical assessment to ensure social and ethical desirability.

Before we investigate the social acceptance and ethical acceptability strategies in depth, we will briefly introduce the general working of the technological system, potable water reuse, and the chosen case studies that are currently underway implementing such a system: the cities of San Diego, Scottsdale and Phoenix.

3. Background: Potable water reuse and current case studies

To provide context for the subsequent analysis of social and ethical acceptability, this section introduces the technology of potable water reuse. Potable water reuse involves treating wastewater to meet drinking water standards using advanced technologies. Unlike traditional reuse methods, which return treated water to natural systems or use it for non-potable purposes, potable water reuse integrates treated wastewater into water supply systems (United Nations, 2017). Indirect potable reuse (IPR) utilizes environmental buffers like reservoirs or aquifers for storage, while direct potable reuse (DPR) bypasses these buffers entirely (Gerrity et al., 2013; Voulvoulis, 2018). While IPR has been widely adopted in places like the U.S. and Australia, DPR is only gaining traction as a solution to water scarcity (Santos, Pachawo, Melo & Vieira, 2022).

As such, the population of suitable of suitable cases is relatively limited, and we have taken an explorative research design. The selected cases, Phoenix, Scottsdale, and San Diego, have been found to provide variety in terms of their maturity. The cities of San Diego, Scottsdale, and Phoenix represent different stages of implementing potable water reuse to address water scarcity challenges. San Diego is in its construction phase, Scottsdale is in its demonstration phase, and Phoenix is in the planning phase. San Diego, heavily reliant on imported water (90 % from northern California and the Colorado River), faced public and political resistance to potable water reuse in their first introduction attempt in the late 1990s (Bridgeman, 2004; Hartley, 2006). Through initiatives like the 2010 Water Purification Demonstration Project, stakeholder interviews, city hall meetings and news coverage, public trust was rebuilt, leading to the creation of the Pure Water Program. Approved in 2014, this program aims to meet a third of the city's needs by 2035 (City of San Diego, 2023).

Scottsdale and Phoenix are neighboring central Arizona cities, facing increasing water scarcity due to prolonged droughts and population

growth (City of Phoenix, 2021a). Here, Scottsdale has taken the lead in potable water reuse and has transitioned from IPR for irrigation to launching Arizona's first DPR demonstration facility. This shift was enabled by regulatory changes in 2018, allowing DPR permits. Public outreach strategies, such as tasting events and collaborations with breweries, aim to foster trust and acceptance (Schneider, 2022; McNamara, 2023). Phoenix, on the other hand, is still in the feasibility stage of DPR implementation. Yet, the city has long utilized reclaimed water for non-potable uses. Recently, it allocated \$30 million to retrofit the Cave Creek Reclamation Plant for DPR despite incomplete regulatory frameworks (Cahill, 2023). Collaborative projects with neighboring cities and public engagement efforts are underway, but remain in the early development stages.

Data collection took place during a research visit of the lead author in Phoenix and San Diego in the Spring of 2023. The used data sources include an extensive review of documents, reports, videos and online materials available through official water utility channels. Individuals prominently featured in this content, especially policymakers and practitioners actively engaged in water reuse initiatives, were identified as potential participants. Furthermore, a semi-structured interview methodology has been employed to gain insights from decision-makers, stakeholders, and academics involved with potable reuse projects. The interviews focused on participants' attitudes toward public participation, their valuation of public outreach activities, their expectations regarding outreach outcomes, and their perceptions of the impact on public views concerning potable water reuse. To identify potential interviewees, five methods have been used: reviewing water utility content, researching governmental decision-makers, leveraging existing networks, recruiting at the AZ Water Conference, and using the snowball effect.

We have aimed to safeguard research ethical standards by obtaining informed consent from participants, offering research transparency, and ensuring data security. Before conducting the interview, each interviewee has been given an informed consent form and ample time for questions. Participation was voluntary, and no compensation was offered. Post-interview and transcription, we enhanced transparency and accuracy by sending interview summaries to participants for member checks. This iterative process provided an opportunity for clarification or revision of our interpretations. In our dedication to preserving participant confidentiality, we implemented secure and anonymous data processing methods, including anonymizing transcripts and aggregating information when anonymization alone may not sufficiently protect privacy. All data was securely stored on institutional cloud services, with personal details kept separate from interview transcripts, and upon completion of the study, all personal data was permanently destroyed.

4. Social acceptance

This section examines how the challenge of gaining social acceptance has been approached in potable water reuse projects. It explores the methods used, their underlying assumptions, their strengths and weaknesses, and ultimately argues that a focus on social acceptance alone is insufficient for responsible technology implementation. We will analyze two distinct approaches to social acceptance in the context of potable water reuse: *Common participation approaches*, as exemplified by the city of Phoenix, and *Opening Up participation*, as demonstrated by the efforts of Scottsdale.

4.1. Common participation – A starting point

Public participation, in its ideal form, is a process that empowers the public to engage in meaningful dialogue and decision-making regarding issues that affect their lives. Generally, participation is an ambiguous concept which can encompass a range of activities, from information sharing to collaborative problem-solving (Arnstein, 1969; Cornwall,

2008). However, in developing and implementing new technologies, participation has often been shown to take on a more limited form, frequently presented as an educational effort to inform the public about a chosen technology's benefits (Wynne, 1992). As such, participation can be strategically deployed to legitimize pre-existing power structures, with 'invited' spaces for engagement ultimately serving the interests of those who initiated them (Cornwall, 2008; Pesch, 2019). Participation then quickly becomes a strategy to secure public acceptance for a pre-selected technological choice rather than a genuine exploration of alternatives or a mechanism to incorporate public concerns into the design process (Irwin, 2006; Rowe & Frewer, 2000; Stirling, 2008). We will illustrate this common participation approach with the Phoenix case study.

Phoenix has formally approved a DPR project on the Cave Creek Plant at 91st Avenue, signaling a commitment to this technological solution (Seely, 2024). This initiative involves collaboration with neighboring cities of Tempe, Mesa, and Scottsdale. The public outreach campaign for Phoenix's DPR project is still in its early stages. Officials have acknowledged the importance of engaging the public to build support for the project, but concrete outreach strategies are still being developed. The absence of a dedicated potable water reuse outreach website, documents on stakeholder involvement and social media channels indicates a centralized, top-down approach to implementing DPR. Instead, current information on the project focuses on DPR's safety, technical processes, and necessity, emphasizing the region's water scarcity due to prolonged drought and low Colorado River levels (see, e.g., City of Phoenix, 2021b, n.d.).

To increase social acceptance, public participation strategies are mostly based on education efforts (Harris-Lovett et al., 2015; Moesker, Pesch & Doorn, 2024b). Phoenix seems to be approaching its communication regarding water scarcity and potable water reuse similarly (City of Phoenix, 2021a; Fischer, 2024), pointing to assumptions that might be embedded in Phoenix's approach. Communicating safety is a high priority for the city, and it is addressed through an expansive education strategy utilizing various channels such as websites, social media, and events where residents can taste the water and interact with important decision-makers. For tasting events, however, the assumption is that positive sensory experiences will build trust and address safety concerns without fully engaging with residents' deeper questions about potable reuse. These activities indicate that it is believed that misinformation or ignorance is the source of resistance, which can be resolved by targeted communication. Such an approach, also called the knowledge-deficit model, implicitly assumes that public acceptance can be achieved by 'correcting' these knowledge gaps. While evidence of potable water reuse studies indeed suggests that additional information can increase acceptance (see, e.g., Fielding, Dolnicar & Schultz, 2019; Fielding & Roiko, 2014; Prins, Etale, Ablo & Thatcher, 2022), there is also evidence that suggests that this effect is overly emphasized concerning other factors (see, e.g., De Koster & Achterberg, 2015; Leong & Lebel, 2020). Extensive literature outside the potable water reuse field has shown that the knowledge-deficit model alone is rarely sufficient to represent technology-related social concerns (Blake, 1999; Wynne, 1992). Such concerns about potable water reuse often extend beyond technical safety to encompass broader issues such as trust, equity, and the 'Yuck factor' (Moesker et al., 2024b; Ormerod & Scott, 2013). Critically, Phoenix's reliance on an educational approach reflects broader patterns seen in common participation methods that aim to close down on a pre-determined solution (Stirling, 2008). These methods tend to engage only established stakeholders, who represent expected societal concerns, while excluding marginalized groups or emerging movements that may raise new values or issues (Pesch, 2019).

The shortcomings of Phoenix's strategy are emblematic of what Batel, Devine-Wright and Tangeland (2013) describe as a conflation of passive acceptance with active support. By prioritizing the project's advancement over inclusive dialogue, the city risks neglecting the broader societal implications of potable water reuse. This approach

aligns with van de Poel's observation that acceptance garners attention only when it is assumed to become a barrier (Van de Poel, 2016). This tendency can be traced back to Phoenix's underlying reason for collecting the needs and concerns of the public – they are used to improve engagement materials to better convey the safety and future benefits of the technology to the public.

The decision to use public participation instrumentally to secure acceptance reflects a broader reluctance to adopt more inclusive engagement strategies. The motivation for this appears to be the belief that more inclusive approaches require too much time and may contribute to unintended outcomes such as project delay or the non-use of the system. As a result, common public participation methods are often top-down, one-way communication exercises aimed at managing public perception rather than a genuine effort to understand and address diverse public concerns about the technological solution. With that, public engagement is used to build superficial acceptance to quickly move the project toward the implementation phase because, once a technology has been implemented, "people accept all sorts of unwanted outcomes" (Cowell, Bristow & Munday, 2011).

4.2. Opening Up participation

Opening Up participation offers a more inclusive and deliberative model for engaging the public in technological decision-making (Fiorino, 1990). This approach directly addresses the shortcomings of common participation strategies, which often prioritize securing acceptance over genuine dialogue and marginalizing dissenting voices. It deliberately expands decision-making processes to include a broader range of perspectives, values, and knowledge sources, where public concerns and ideas shape the project's trajectory (Stirling, 2008). Here, starting participation early or 'upstream' in the project lifecycle, ideally before key decisions are made, allows public input to have a more meaningful impact (Rowe & Frewer, 2000; Wilsdon, 2004).

The city of Scottsdale provides an example of attempting to incorporate more inclusive and deliberative engagement strategies in its potable water reuse project. Scottsdale obtained a permit for a demonstration facility after Arizona relaxed its ban on producing recycled water for human consumption in 2018 (Scottsdale Water, 2023a). The city's strategy emphasizes proactive community engagement and educational initiatives to foster public trust and support for the DPR initiative. Recognizing the potential hesitancy towards potable reuse, the city built a pilot plant to raise awareness and overcome the 'yuck factor', stressing that there were no immediate plans to connect it to the water supply (Brodie, 2019). With this, the city's participation efforts started almost a decade earlier than Phoenix by hosting community forums, focus groups, and stakeholder workshops (see, e.g., Schneider, 2022; Tenney, 2018). Moreover, tasting events have been facilitated, such as Canal Convergence (see, e.g. Schneider, 2022) and collaborations with local breweries (McNamara, 2023).

These initiatives reflect a growing awareness that public participation must go beyond education to uncover latent societal concerns and priorities. However, while these participatory initiatives can potentially broaden the decision-making process substantively, they remain susceptible to being captured by dominant power structures and political objectives. This dynamic can be traced back to the way Scottsdale representatives frame the discussion of potable water reuse in the media, highlighting positive outcomes like water security, high water quality, and progress in overcoming the 'Yuck factor' (see, e.g., Backer, 2022; Brodie, 2019; Scottsdale Independent, 2019) but giving less attention to potential risks and costs. This approach suggests that the primary goal of this public communication is to gain acceptance rather than to provide a balanced assessment of potable water reuse's costs and benefits.

This critique highlights a broader issue within social acceptance frameworks: the absence of tools to evaluate the moral desirability of participatory approaches in practice. Current frameworks are primarily descriptive, focusing on goals and processes (see, e.g., Fielding et al.,

2019; Katz & Tennyson, 2015) rather than interrogating the ethical dimensions of participation methods. As a result, social acceptance methods run the risk of resorting to morally questionable practices to achieve their pre-defined aims. In Scottsdale's case, while the opening-up efforts may provide a platform for a broader range of societal concerns and perspectives, the induced positive bias may hide important problems such as rising water prices and remaining concerns regarding the environmental impact of treatment plants (see, e.g., Ahmad & Baddour, 2014; Gerrity et al., 2013). With that, even when orienting at Opening Up participation, a strong emphasis on increasing social acceptance can risk the implementation of technologies that may ultimately be unsuitable for a particular society.

5. Ethical acceptability

To determine the desirability of technological development, it may not suffice to invite members of society to speak out. In the case of a wicked problem, there is normative uncertainty, meaning that there are different ideas about what is 'good', but also different approaches to disclosing the question about what is 'good'. The exclusive reliance on the input of invited participants, who are confined by concrete spatial and temporal boundaries, disregards the heterogeneity of approaches to address normative questions, among which are the methods developed in the field of ethics. This reliance testifies to the reluctance to deploy approaches from ethics to deal with wicked problems (Pesch & Van Uffelen, 2024).

Ethical analyses of controversial technologies such as nuclear energy (Taebi, Lagendijk, Dekker & van Est, 2024) and nanotechnology (Van de Poel, 2009) have shown that the assessment of a technological system's ethical acceptability can be seen as complementary to the evaluation of its societal acceptance (Moesker et al., 2024a). In this, ethical acceptability can be defined as a "reflection on a new technology that takes into account the moral issues that emerge from its introduction" (Taebi, 2017). Despite its recognized importance, ethical acceptability remains relatively under-researched compared to the extensive body of work on technology acceptance (Gauttier, 2019).

It is difficult to find an explicit 'method of ethics' in the literature, and the question about the ethical acceptability of new technologies has, as yet, only received scattered attention. So, while we fully embrace the need to attend to these matters, we can only outline some explorative starting points about the integration of ethical concerns in discussions on the acceptability of new technologies at this moment.

In this, we can start with the observation that the implicit method of ethics is based on the pursuit of eradicating contingent factors from our reasoning (Pesch, 2024). While acknowledging that a genuinely impartial perspective is an ideal that can never be effectuated, one may see a range of approaches developed that allow the normative assessment of real-life phenomena from an outsider's perspective. With that, ethical approaches help us to overcome the blind spots of social acceptance approaches.

It is important to emphasize that ethical approaches do not rule out the participation of societal actors. In fact, the involvement of such actors can be seen as a suitable approach to pursuing an impartial position: the exchange of perspectives of diverse actors helps to reduce bias. The key difference with conventional participatory approaches to social acceptance is that the outcome of a participatory process is not to be seen as a final result but as a stepping stone towards a 'more impartial' position (Roesser & Pesch, 2016; Swierstra, Stemerding & Boenink, 2009).

5.1. Ethical participation

As said above, the ideal of ethics is to arrive at a point of view that is independent from any particularistic interest. Though this ideal seems to be unattainable, we may converge to it by acknowledging a range of perspectives, values and concerns that is as broad as practically feasible.

Based on this consideration, we introduce the notion of 'ethical participation', which extends the principles of Opening Up participation by explicitly incorporating a broader set of societal values. Participatory methods are based on the involvement of agents who are able to speak out, while future generations or nonhuman agents have no voice (yet). Such exclusion of such agents is not a mere matter of lacking representation; it also means that it misses out on perspectives and concerns that are relevant. As such, ethical participation acknowledges that participation of the many is not a panacea to technology development, but emphasizes that the methods used to engage stakeholders must be ethically sound.

No method for ethical participation appears to exist as of yet. As such, the remainder of this section explores how ethical considerations can be integrated into decision-making processes, starting with ethical participation and closing with Opening Up the problem space. From our cases, we try to derive participatory activities that appear to either converge towards or diverge from the inclusion of ethical concerns in determining the acceptability of new technologies.

San Diego has made notable strides in incorporating a wide range of stakeholders in its potable water reuse program called Pure Water. The city has proactively contacted various participants, including environmental organizations, community leaders, governmental bodies, and the general public (City of San Diego, 2025; Rea & Parker Research, 2011). Organizations such as the Surfrider Foundation, which advocated for more stringent environmental safeguards, have been actively involved in the project's progress, showing the city's awareness of potable water reuse's environmental concerns (see, Occiano & Strayer, 2012). Including non-human entities – through representative environmental stakeholders such as Surfrider – has been critical to San Diego's approach, making its strategy an example of how ecosystem concerns can be better represented alongside human interests.

Already in the 1990s, city officials proposed introducing reclaimed water into the potable water supply, which led to political debates and public resistance. Concerns about public health risks, socio-economic disparities, and the project's costs led to its cancellation (Hartley, 2006; Po, Nancarrow & Kaercher, 2003). Nevertheless, San Diego reintroduced a project for water reuse in 2002, which was accompanied by the Long-range Water Resource Plan included an extensive Public Outreach Program plan that started in 2010. This effort was paired with the Water Purification Demonstration Project and numerous initiatives, including public opinion polls, interviews, and surveys, to ensure a broad and inclusive engagement approach (City of San Diego, 2013). San Diego's potable reuse project, known as Pure Water San Diego, has advanced significantly in recent years. Being unanimously approved by the city council in 2014, the building phase started in 2021, with the first phase expected to be completed by 2025 (City of San Diego, 2023).

Despite these efforts, San Diego's approach to participation still faces limitations. One challenge is the reliance on community leaders to represent entire communities, which may not always be a true reflection of the diverse perspectives within those communities (Pesch, 2019; Wynne, 2007). Additionally, stakeholders chosen through this method are often those who are already more likely to support the technology or have vested interests, which could lead to biased input and the exclusion of voices that may express opposition or concerns about technology-induced impacts (Stirling, 2008). This highlights the critique that stakeholder lists, like those in San Diego, are static and may not fully account for emerging societal concerns or marginalized groups who have not been actively included in the process (Moesker & Pesch, 2022).

Moreover, while San Diego has worked to include a broad range of stakeholders, the concept of 'affected' parties remains challenging to define. The boundaries set by service areas or geographic limits can exclude people who may be indirectly impacted by the technology. This limitation is especially significant when considering the potential global impacts of potable water reuse systems. For example, sourcing materials for these systems or the long-term effects of their operation on water

cycles could affect communities far beyond San Diego's borders. Furthermore, future generations, human and non-human, are typically underrepresented in these processes, raising questions about intergenerational justice and the rights of those not yet born. While commendable in its attempt to incorporate some aspects of ethical participation, such as the attempt to incorporate non-human entities, San Diego's approach can be critiqued for failing to address concerns outside its geographic and temporal boundaries.

While ethical participation represents a significant improvement over traditional and Opening Up approaches by broadening the range of stakeholders considered, it typically still operates within a pre-defined problem space. This problem space often reflects existing power structures and assumptions about the public's concerns and needs, potentially limiting the underlying roots of the challenge at hand and its associated implications. Therefore, a more holistic socio-ethical assessment also requires addressing what is being discussed in the public debate. We argue that these concerns necessitate an Opening Up of the problem space.

5.2. Opening Up the problem space

While ethical participation aims to broaden the range of stakeholders to incorporate often overlooked considerations into the decision-making process, it often operates within a pre-defined problem space. In the case of potable water reuse, the problem to be solved is frequently framed as regional 'water shortage,' aligning with the traditional, supply-focused approach of water planners, who have historically prioritized identifying and meeting growing human demands for water (Gleick, 2003). This problem framing rests on the premise that the core problem at hand is a lack of available water within that region. Hence, increasing supply through a new water source – recycled water – appears to be an inherently logical solution.

We argue that 'water shortage' cannot be equated with 'water scarcity' as it overlooks the inherent 'wickedness' of water scarcity. This oversimplification of the problem becomes more apparent when looking at Quentin Grafton's (2017) definition of water scarcity as "water misallocation where [...], multiple pathways to water reallocation and substantial uncertainty over the consequences of business as usual and alternative futures" (p.3025) exist. As such, the 'wickedness' of water scarcity necessitates a shift of the problem frame from simply needing to find more water to examining how water is currently used, managed, and distributed.

Nevertheless, current public engagement strategies in potable water reuse projects often resort to the simplistic problem space of 'water shortage'. For example, public engagement strategies surrounding potable water reuse in the Phoenix region (including Scottsdale) narrow the problem further down to 'drinking water shortages'. The framing that is employed here obscures alternative strategies, such as saving water from other water-consuming sectors, particularly agriculture and landscaping. Although these sectors have shown increased efficiency in water use and more sustainable innovations, they continue to consume significant amounts of water, often justified by claiming to use 'non-potable' sources (see, e.g., Kelley, 2018; Scottsdale Water, 2023b), which do not compete with drinking water demands. This framing is problematic because the distinction between potable and non-potable water sources creates a boundary where the excess use of some 'non-potable' water sources seems to remain largely unquestioned. Yet, the increasing uptake of potable water reuse systems highlights that this distinction is merely artificial, but helps reinforce the status quo of water-intensive, partially non-essential practices like golf course irrigation, large-scale landscaping and water-intensive agriculture such as citrus fruits.

Moreover, the narrow focus on water shortage risks overlooking crucial ethical concerns and uncertainties inherent in our current water management systems concerning *how water is currently used, managed, and distributed*. Potable water reuse systems have been developed to be

compatible with the current Western water management system. Hence, potable water reuse represents an incremental innovation that supports our current water management system, which perpetuates critical sustainability concerns such as using highly treated, potable water for watering lawns, flushing toilets, showering, and washing clothes – activities that do not require drinking water quality yet cost significant amounts of resources and energy due to the high water quality. The wastefulness of our current water management system remains frequently unacknowledged. Particularly in Western societies, there is a pervasive, often unquestioned, assumption that our centralized, infrastructure-heavy approach to water management is inherently 'good' or 'advanced' (Meehan et al., 2020), masking the sustainability issues of these systems.

The increased circularity of potable water reuse systems offers a seemingly more sustainable solution. However, they risk perpetuating the unsustainable aspects of current water management. By allowing the continuation of current consumption patterns (e.g., overconsumption or using potable water for non-potable purposes) and failing to address infrastructure issues (e.g., leakages), the costs of our current water management systems appear to remain largely unchallenged. The substantial investments in new pipelines and advanced treatment technologies (e.g., reverse osmosis) for potable water reuse could further entrench path dependency, making it more difficult and costly to transition to alternative water management strategies.

Hence, it can be argued that potable water reuse, as an incremental innovation, only deepens the technological lock-in of these unsustainable water management systems. Here, technological lock-in describes the situation where a technological system stays dominant not necessarily due to its superiority but because of established infrastructure and interdependent systems that make alternatives less viable (Arthur, 1989; Callon, 1990). Infrastructures are prone to lock-ins because of their large-scale, long-term investments, deeply embedded social practices and institutional arrangements, creating a self-enforcing system (Helmrich, Chester, Miller & Allenby, 2023). Especially, techno-centric strategies help reinforce current water infrastructure systems, thereby risking the exacerbation of ecological and social vulnerabilities (Markolf et al., 2018).

Yet, the ecological and social vulnerabilities may be significant. Regarding ecological vulnerabilities, discussions about potable water reuse often overlook the potential impacts and uncertainties associated with the new waste streams generated by these advanced treatment processes. The concentrated brine, a byproduct of technologies like reverse osmosis, contains high levels of salts, minerals, and potentially harmful contaminants. Current disposal methods in Arizona, such as evaporation ponds and discharge into the sewer system (Hummer & Eden, 2016), have limited capacity and pose significant environmental risks; evaporation ponds consume large areas of land and can pollute soil and air (Amoatey et al., 2021), while sewer discharge will become increasingly problematic as potable water reuse scales up (Hummer & Eden, 2016). Moreover, the discharge into oceans or rivers, another common method, can severely harm aquatic ecosystems (Ahmad & Baddour, 2014). Therefore, the long-term environmental sustainability of potable water reuse's generated waste stream remains a critical and unresolved concern.

Regarding social vulnerabilities, the narrow focus on potable water reuse as a technological solution can exacerbate existing inequalities or introduce new ones. A typically mentioned concern of current centralized water management systems is the issue of affordability. While water affordability has long been a concern of the United Nations, particularly in less developed countries, developed nations also face affordability challenges, especially for low-income households (see, e.g., Mack & Wrase, 2017; Vanhille, Goedemé, Penne, Van Thielen & Storms, 2018), which are likely to exacerbate in the future (Teodoro & Saywitz, 2020). The large-scale adjustments in infrastructure and technologies needed for potable water reuse and its high energy consumption when in operation induce high costs (Gerrity et al., 2013; Lee & Jepson, 2020),

impacting low-income households and communities the most. However, research on affordability is lacking due to the low number of operational plants. Moreover, there is a hot debate about the cost of alternatives, such as desalination, being claimed as significantly more costly than potable water reuse (Expósito, Lorenzo Lopez & Berbel, 2024; Mattingly, Raucher & Tchobanoglous, 2015).

Hence, the dominant reduction of the problem of water scarcity to water shortage narrows the problem space towards focusing on technological solutions that increase supply, such as potable water reuse. This narrow framing aligns with traditional water planning and obscures the ‘wickedness’ of water scarcity and its corresponding social and environmental concerns. Without Opening Up the problem space, these aspects often do not come to light when considering potable water reuse as a technological solution. As a result, pursuing social acceptance within this limited problem space risks perpetuating unsustainable practices and hindering the development of more desirable solutions.

6. Conclusion

This paper has contended that achieving social acceptance, while often considered the primary goal for the governance of new technologies, is insufficient to determine the desirability of technological developments. Especially for ‘wicked problems’ like water scarcity, current governance approaches that focus solely on social acceptance risk overlooking crucial ethical considerations, thereby potentially reinforcing unsustainable practices. By using potable water reuse projects in Phoenix, Scottsdale, and San Diego as illustrative cases, we could explore how even Opening Up participation strategies are susceptible to manipulation and risk neglecting the needs of marginalized groups, future generations, and non-human entities. To address these deficiencies, we proposed a socio-ethical assessment framework as a tool for more responsible governance that integrates social acceptance measures with considerations of ethical acceptability. This framework emphasizes the importance of ethical participation, prioritizing the moral quality of engagement processes and broadening the stakeholder scope. Additionally, it calls for Opening Up the problem space by challenging the initial framing of the problem to be solved and acknowledging the inherent complexities and uncertainties associated with wicked problems like water scarcity, as well as social and environmental uncertainties. With this socio-ethical assessment approach, we hope to support technology developers and policymakers in guiding the development of technologies that are socially accepted by the public and ethically desirable for society and the environment.

We need to emphasize the novelty of our framework; its main goal is to set the agenda for future research. Currently, studies that systematically bridge participatory decision-making and ethics appear to be lacking. The goal of our work has been mainly explorative, and detailed governance implications cannot yet be given. As such, the most important lesson that we want to convey for now is one of raising awareness. It needs to be acknowledged that for most governmental actors, the appeal for opening up opposes their inclination to close down decision-making processes. Likewise, the institutional context in which they work can be seen as ‘closing down’ machines (Ruiten et al., 2023). Moreover, participatory methods are often used in an instrumental fashion, and ethical concerns tend to be reduced to stakeholder opinions. However, decision-makers are also increasingly aware of the ‘wickedness’ that characterizes the introduction of new technologies, and become more receptive to include a broader range of concerns, even if that means that they have to step out of their comfort zone (cf. Melnyk, Taebi, Gammon, Hutton & Pesch, 2025). Researchers should use this receptiveness to implement new approaches and show their potential and efficacy. At the same time, governance actors should realize that participatory methods do not guarantee the legitimacy of decisions regarding wicked problems, and quick fixes are not to be expected. We invite researchers and decision-makers to collaborate to create and test different frameworks and methods for such assessment. With such a co-creative approach, we

can move towards the development and refinement of practical methodologies to integrate ethical acceptability into technology governance processes and systems, such as potable water reuse. Concrete tools and guidelines for conducting ethical participation and facilitating deliberative processes need to be developed that effectively Open Up the problem space surrounding wicked problems like water scarcity. This could include developing normative methods for evaluating the long-term social and environmental impacts of different technological pathways to inform governance and decision-making better, incorporating a broader range of ethical considerations and uncertainties.

CRedit authorship contribution statement

K. Moesker: Writing – review & editing, Writing – original draft, Conceptualization. **U. Pesch:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Karen Moesker reports financial support was provided by Netherlands Organisation for Scientific Research Division Humanities. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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