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Research article

Responsible mission governance: An integrative framework and research agenda

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ABSTRACT

Governance lies at the heart of instigating, steering, and creating the conditions for mission-oriented transitions that potentially help resolve some of our grand societal challenges. In doing so, policymakers will need to navigate both epistemic and normative considerations to develop, implement, and evaluate missions responsibly. A number of scholars have therefore expressed the need for a better conceptualization of responsible mission governance as a procedural approach, particularly with the aim of coping with the *complexity*, *uncertainty*, and *contestation* that render these wicked problems *intractable*. In this paper we develop an integrative framework for responsible mission governance by taking wickedness dimensions as our entry point. Accordingly, we argue that responsible mission governance should integrate various complementary governance responsibilities (e.g., reflexivity) and modes (e.g., reflexive governance) that potentially improve the effectiveness and desirability of missions. We conclude by discussing urgent avenues for future research

1. Introduction

The past years have witnessed a renewed interest in mission-oriented innovation policy (MOIP) as a policy approach to address grand societal challenges like climate change, pandemics, and social injustice (Mazzucato, 2018). MOIP uses “an urgent strategic goal that requires transformative systems change directed towards overcoming a wicked problem” (Hekkert et al., 2020, p. 1).

It is precisely the wickedness of societal challenges (Rittel and Webber, 1973) that poses a substantial ‘governability’ issue to policymakers (Jentoft and Chuenpagdee, 2009; Wanzenböck et al., 2020). In developing policies, they need to navigate both epistemic considerations (e.g., pluralities of knowledges, experiences, insights) and normative considerations (e.g., pluralities of values, concerns, and principles such as equity, fairness, justice) in order to promote transformative change that is deemed both effective and desirable.

In this context, the notion of mission governance largely refers to the processes that serve to develop, implement, and evaluate these policies, and which set the conditions that are conducive to transitions (Patterson et al., 2017). However, questions such as “who makes

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decisions, what is considered a desirable future, and (even if we assume consensus) how do we get there[?]" remain unresolved (Patterson et al., 2017, p. 8). Simply 'pulling' or 'pushing' solutions into society without caution, deliberation, and ethical consideration risks inducing 'failures' and 'dark sides' of transitions (Blythe et al., 2018; Turnheim and Sovacool, 2020). In addition, transition governance at large has been criticized for under-appreciating normative issues (Kirchherr et al., 2023; Smith and Stirling, 2010). These struggles raise the question of how missions can be governed more responsibly (Klerkx and Rose, 2020) by better coping with the core wickedness dimensions of the problems they intend to address (i.e., complexity, uncertainty, and contestation; Janssen et al., 2021; Wanzenböck et al., 2020).

Such questions are important because these mutually reinforcing wickedness dimensions render problems intractable – that is to say, incomprehensible and unmanageable – and commonly lead to ineffective and irresponsible outcomes (Head, 2019; Mueller et al., 2023; Snowden and Rancati, 2021). Because missions target wicked problems, policymakers are in need of novel mission governance frameworks that help them more responsibly cope with wickedness when developing, implementing, and evaluating missions (Hekkert et al., 2020).

This paper aims to address the need for such a framework. In what follows, we will use complexity, uncertainty, and contestation – three broadly recognized wickedness dimensions – as our entry points for the development of an integrative framework for responsible mission governance. We do so by linking existing governance responsibilities (e.g., inclusion) and governance modes (e.g., participatory governance) with these dimensions to help policymakers better cope with wickedness, and to subsequently benefit the effectiveness and desirability of missions (Section 2). Hereafter, in Section 3, we argue in favor of integrating these responsibilities and modes for mission governance, after which we discuss what this could mean in the multi-level context of missions (Section 4). In Section 5, we apply and reflect upon our framework through an illustrative vignette. Lastly, Section 6 proceeds by discussing important avenues for future research before we end with concluding remarks in Section 7.

2. Procedural approaches to coping with wickedness: governance responsibilities and modes

So-called 'transformative' or 'transformer' missions target societal challenges that require fundamental socio-technical, institutional, and behavioral transformations of our society (Hekkert et al., 2020; Wanzenböck et al., 2020; Wittmann et al., 2021). They prioritize bold, clear, and ambitious goals to evoke cross-boundary and distributed responses (Mazzucato, 2018) and aim to set the conditions that potentially bring about relatively open-ended and non-linear transitions (Köhler et al., 2019). The European Commission has already developed and implemented five of such missions, which collectively represent investments of over a 100 billion Euros (European Commission, 2022). Many countries such as Japan, the United Kingdom, and The Netherlands have similarly launched their own transformer missions (Larrue, 2021).

Missions and the associated formulations and strategies are social constructs that are co-produced across policy, science, and society, and which inscribe performative visions about the future world (Wiarda et al., 2023a). Mission governance will need to mobilize and coordinate stakeholders to successfully develop, implement, and evaluate missions (Janssen et al., 2021). In such efforts, it is important to pay attention to "the structures, processes, rules and traditions that determine how people in society make decisions and share power, exercises responsibility and ensure accountability" (Patterson et al., 2017, p. 3).

An increased awareness has emerged that the transitions encouraged by mission governance are not value-neutral (Kok and Klerkx, 2023). The associated mission strategies come with strong normative visions of what future societies should look like, even if this normativity is not widely shared by society. As with any attempt to deliberately drive transformative change, pursuing missions may lead to potential transition failures, disruptions, and 'dark sides' (Blythe et al., 2018; Geels and Schot, 2007; Turnheim and Sovacool, 2020) and risks generating maladaptive outcomes that reinforce, redistribute, and create vulnerabilities across communities (Blythe et al., 2018; Eriksen et al., 2021; Lennon, 2017). For instance, while policy-supported solutions like solar panels play a crucial role for the energy transition, resources required for their production tend to be mined by people from low-income countries who suffer from poor working conditions (Zehner, 2012). Transitions are moreover associated with creative destruction (Schumpeter, 1934), power shifts (Morrison et al., 2017), and labor shifts (Sharma and Banerjee, 2021). Blythe et al. (2018) subsequently ask: "who gains and loses, who has agency and who decides about the trajectory, rate and scale of changes?" (p.1218). Similarly, scholars have expressed ethical concerns and advocate for fair and just transitions (Moglia et al., 2021; Wang and Lo, 2021; Yalaw et al., 2021). For example, the abovementioned illustration about solar panels underlines the need for explicit attention to distributive justice, that is to say, whether (un)desirable impacts of missions are shared fairly among stakeholders, and according to whose perspective. These questions are both of ethical and instrumental nature as the success of missions depends on the trust, legitimacy, input, and broad support from stakeholders (Elzinga et al., 2023).

Many undesirable and unintended consequences of challenge-led policies are the result of the persistent *complexity*, *uncertainty*, and *contestation* associated with wicked problems, and which subsequently give rise to *intractability* (Farrell and Hooker, 2013; Ferraro et al., 2015; Head, 2022, 2019; Wanzenböck et al., 2020). Although intractability is neither a wickedness dimension nor a synonym for wickedness,¹ it is an important consequence of the three wickedness dimensions and therefore requires explicit consideration (Head, 2022).

To understand how policymakers can better cope with complexity, uncertainty, contestation, and intractability, it is important to make a distinction between substantive and procedural forms of governance (Head, 2022; Head and Xiang, 2016). Substantive

¹ We recognize that problems can be intractable without being wicked. For instance, relatively tame problems that are characterised by high degrees of complexity, but low degrees of uncertainty and contestation.

governance generally focusses on outcome-driven policies, whereas procedural governance centres around the underlying and continuous processes that lead up to the development, implementation, and evaluation of policies (Bali et al., 2021). Substantive governance has been heavily criticized in the wicked problems literature because it tends to merely cure a problem's symptoms without addressing the deeper interrelated constellation of problems (e.g., Churchman, 1967; Dery, 1984; Head and Xiang, 2016; Hoppe, 2011; Termeer et al., 2019). In contrast, procedural governance, as a way of 'working with' wicked problems, requires policymakers to "enter into a deep, mutual understanding of the untamed aspects of the problem" before defining substantive outcomes (Churchman, 1967, p. 142; Head and Xiang, 2016). Accordingly, Wanzenböck et al. (2020) emphasize this importance in their plea for a process-oriented view on mission governance, stating that "to find effective solutions for ill-defined societal challenges, more dynamic, and flexible [policy] approaches are needed" (p.484).

In what follows, we will use complexity, uncertainty, and contestation and the resulting intractability as our entry points for the conceptualization of responsible mission governance as a procedural approach (c.f., Bali et al., 2021; Head and Xiang, 2016). The emphasis of this framework lays on helping policymakers 'cope with' or 'work with' wickedness more responsibly when governing missions that are directed toward wicked problems – that is to say, to govern missions in greater accordance with stakeholder values and worldviews. After discussing how a given wickedness dimension problematizes mission governance, we will argue which particular governance responsibility is most pertinent (i.e., inclusion, anticipation, reflexivity, and responsiveness). This points at the relevance of at least four existing governance modes suitable for addressing these governance responsibilities (i.e., participatory, anticipatory, reflexive, and tentative governance, respectively). These modes stem from distinct fields of research that specifically incorporate the aforementioned responsibilities into governance, but which have not yet been combined into an integrative framework for addressing wicked problems. These four governance modes partly overlap (e.g., in how they are enacted), and therefore may also be relevant for responsibilities other than the one they were developed for. For each governance mode, we will provide implementation-related suggestions and research avenues.

2.1. Managing complexity with participatory governance

The complexity of wicked problems stems from their multitude of dimensions, actors, and scales that are constantly changing (Wanzenböck et al., 2020). In contrast to complicated problems, complex problems impose an everlasting knowledge deficiency on policymakers regarding the problem's intricacies (Stirling, 2010). Wickedness obscures the division of problems and solutions, as solutions both solve and create problems (Kuk et al., 2023). Agricultural innovations, for example, have both significantly benefited food production and affordability, while simultaneously giving rise to challenges like soil contamination, air pollution, deforestation, and the mutation and spread of infectious diseases. Problems emerge, interact, and co-evolve, and require interventions and coordination across multiple levels of governance (e.g., subnational, national, and supranational; Wanzenböck and Frenken, 2020; Wiarda and Doorn, 2023). This may include interventions across the niche, regime, and landscape levels (Geels, 2002) and draws attention to possible policy coordination failures (Weber and Rohrer, 2012). A major challenge to mission governance is the idea that missions are usually implemented within specific geographical borders while complex 'grand societal challenges' tend to surpass these (Coenen et al., 2015). What is more, wicked problems are so-called 'problems of many hands' (Van de Poel et al., 2012) in which "no actor is in control, but *everyone* is implicated, has agency and therefore is responsible" (Macnaghten et al., 2014, p. 195). Such a collective responsibility, however, does not necessarily imply an equally shared responsibility (Muttitt and Kartha, 2020; Young, 2002).

Coping with complexity calls for inclusive approaches because knowledge, moral judgement, and agency are distributed among stakeholders (Ferraro et al., 2015; Head, 2008). Participatory, collaborative, network, and polycentric governance modes are all relevant because they focus on identifying and leveraging stakeholder values and worldviews (Ansell and Gash, 2008; Morrison et al., 2017; Newig and Fritsch, 2009; Sørensen and Torfing, 2009). In practice, these governance modes may take forms of consultation or participation (Rowe and Frewer, 2005). There are various normative, substantive, and instrumental rationales that motivate why addressing complexity requires mission governance to open up to a more diverse set of stakeholders, such as citizens, (mini-)publics, and civil society organizations (Stirling, 2008; Wiarda et al., 2023b). For instance, these stakeholders can provide lived experiences and contextual insights in relation to the problem's local manifestation and the potential solutions' implementation, all of which will benefit the social robustness of mission strategies and outcomes (Nowotny, 2003). In the context of mission governance, such social robustness refers to the extent to which decisions "are congruent with, or authentically embody, societally deliberated, publicly reasoned values, knowledges, and meanings" (Stirling, 2008, p. 272). In addition, the lack of knowledge that comes with complexity provides that conventional science-based policies are inadequate, and therefore require a greater epistemological breadth (Head, 2019). Policymakers need to draw from other ways-of-knowing to make more inclusive and informed decisions by, for instance, drawing from local, cross-cultural, and cross-disciplinary knowledges (Balanzó et al., 2023). Some scholars have nevertheless argued that transition strategies commonly exclude certain epistemological frames (Cameron et al., 2015). What is more, while missions act as so-called boundary objects by presumably mobilizing stakeholders into a shared direction (Janssen et al., 2023a, 2023b), recent findings suggest that missions do not necessarily mobilize a more diverse set of stakeholders than conventional policies (Wiarda et al., 2023b). While participatory governance helps cope with complexity, this mode also comes with limitations. For example, participatory modes are resource-consuming and may slow down decision-making processes despite the urgency of complex problems (Bommel et al., 2009). Unintended consequences of participatory governance may be caused by unequal stakeholder representation or reinforced power structures. As Turnhout et al. (2020) put it: "the outcomes of participatory interventions can even be paradoxical, reinforcing the problems that they intended to solve but now sanctioned or legitimized by the participatory process" (p.15).

Having such pitfalls in mind, the literature on participatory governance underlines the need for a more inclusive mission governance to cope with complexity (Rabadjieva and Terstriepe, 2021). Future research should examine who is included and excluded in

mission-oriented innovation. The inclusion of non-governmental stakeholders can take place in so-called ‘invited spaces’ like mission arenas (Wesseling and Meijerhof, 2023), deliberate forums (e.g., citizens’ juries; Rowe and Frewer, 2000), and hybrid forums (Callon et al., 2009), all of which could help democratize mission-oriented transitions. A relational and systemic view on such participatory spaces could even reveal their interrelated nature and how they co-produce stakeholder involvement in mission-oriented innovation systems at large (Chilvers et al., 2018). Policymakers may also leverage certain actors, like intermediaries and platform orchestrators, to promote stakeholder inclusion (Ritala, 2023; Wiarda et al., 2023b). The role of such actors in missions has largely been neglected. Participatory governance furthermore calls for a better understanding of multi-level mission governance, and how actors on various levels (e.g. national and sub-national) are represented, coordinated, and included in missions. Scholars have argued in favor of the subsidiarity principle to take decisions as close as possible to the citizen (Wanzenböck and Frenken, 2020). It is unclear, however, what the role of local forms of innovation are in the context of missions. Relevant forms include, but are not limited to, grassroots innovation (Seyfang and Smith, 2007), open innovation (Chesbrough, 2003), participatory innovation (Buur and Matthews, 2008), and user-driven innovation (von Hippel, 2005). In contrast, research could also reveal how specific closing mechanism (e.g., framings) and power imbalances serve to exclude certain stakeholders or may lead to forms of tokenism (Arnstein, 1969). Incumbents may, for example, leverage institutional strategies to exclude entrepreneurs and ‘keep missions on a leash’ (Smink et al., 2015).

2.2. Exploring uncertainty through anticipatory governance

Wicked problems and their solutions carry with them aleatoric, epistemic, and normative uncertainties that problematize mission governance (Head, 2008; Olsson, 2007; Wanzenböck et al., 2020). While problems and solutions may be prone to the statistical randomness that comes with aleatoric uncertainty (i.e., uncertainty related to the physical nature of some processes or phenomena), it is the nature of the latter two uncertainties that causes wickedness. Epistemic uncertainty refers to the unknowns that policymakers face in their ways of understanding problems and solutions. It describes the difficulty of obtaining ‘objective’ knowledge, commonly of scientific or technical character. Epistemic uncertainty implies that policymakers cannot predict future mission impacts, their severity or their likelihood (Hansson, 2009). For instance, it is impossible to predict the socio-ecological repercussions that climate geo-engineering might have, despite its potential for mission attainment (Pidgeon et al., 2013; Vaughan and Lenton, 2011). In addition, policymakers will need to account for (future) gaps in institutionalized norms and rules that will help guide and safeguard the social acceptability of mission-oriented innovations and their associated impacts. Such institutional voids (Hajer, 2003) foreshadow the normative uncertainty that “there is not one unequivocal right or wrong answer to an ethical question regarding risk” (Taebi et al., 2020, p. 2). Normative uncertainty thus describes the difficulty of foreseeing what subjective, commonly value-based, considerations will be of importance in the future. Epistemic and normative uncertainties also interact. For example, they give rise to forms of economic uncertainty – the uncertainty of whether solutions will be technically and economically viable in light of future supply and demand. Given these uncertainties, policymakers face a dilemma on a transition scale, similar to that of the Collingridge dilemma (Collingridge, 1980; Genus and Stirling, 2018). The Collingridge dilemma conventionally describes how innovators are faced with great uncertainties in early phases of development, when their innovations are still malleable, before these become too rigid and too socially embedded to control once innovators have more certainties in later phases of development. A similar phenomenon takes place for mission governance as policymakers face high degrees of uncertainty in early transition phases when they can still control the development of mission formulation and strategies. In later transition phases, however, they may have a greater understanding of the implications of their missions, while mission governance itself becomes more problematic due to lock-ins (Arthur, 1989; Unruh, 2000), path dependencies (David, 1995), and convergence in the problem-solution space (Wanzenböck et al., 2020).

Dealing with uncertainty requires forms of anticipation in which policymakers have to move beyond risk-based governance by also exploring uncertainties, ambiguities, and unknowns to yield a greater degree of preparedness (Hansson, 2009; Hoffmann-Riem and Wynne, 2002; Stilgoe et al., 2013; Stirling, 2010). Such an exploration includes paying attention to how stakeholders are affected in different ways and to different extents. Policymakers may yield this preparedness through forms of anticipatory governance (Guston, 2014; Nelson et al., 2021), revealing pluralities of possible, probable, and desirable futures (Börjesona et al., 2006). Anticipatory mission governance recognizes the multitude of performative expectations (Truffer et al., 2008), visions (Grin and Grunwald, 2000) and imaginaries (Wiarda et al., 2023a) that draw attention to both hard (i.e. quantitative) and soft (i.e., qualitative) impacts (van der Burg, 2009). These ideas about the future are implicitly or explicitly embedded in scenarios (Robinson, 2009; Selin, 2011), technology roadmaps (Kostoff and Schaller, 2001), narratives (Roßmann, 2021), and even science fiction (Stahl et al., 2014) and have discursive and performative power. Their influence on present developments warrants forms of constructive (Schot and Rip, 1997), real-time (Guston and Sarewitz, 2002), and participatory technology assessments (Kaplan et al., 2021) that could help shape mission-oriented transitions in accordance with the values and worldviews of stakeholders.

In light of the importance of anticipatory mission governance, a better understanding is needed of how possible, probable, and desirable impacts of missions are defined, foreseen, and evaluated under high degrees of uncertainty. We wonder what ideas about mission futures are deemed valid and are taken up in mission strategies, and what ideas are excluded instead. In particular, we need insights into how missions and intended outcomes are defined as the ‘right’ outcomes, given the plurality of (evolving) visions for the future that stakeholders hold. Scholars also argue for a greater focus on alternative, more desirable, transition scenarios (Klerkx and Rose, 2020).

2.3. Embracing contestation with reflexive governance

Wicked problems and potential solutions are contested because society is inherently pluralistic, while problems and solutions can

be explained, framed, prioritized, and tended to in myriads of ways (Rittel and Webber, 1973; Wanzenböck et al., 2020). Missions likewise suffer from interpretative flexibility (Janssen et al., 2023a, 2023b) and can meet the preferences of one stakeholder while opposing those of others (Pesch and Vermaas, 2020). Value change (Van de Poel et al., 2022), value pluralism (Anderson, 1993), and value conflicts (Friedman et al., 2006) exacerbate contestation in the problem-solution space, commonly leading to unsound responses by policymakers (Wanzenböck et al., 2020; Wiarda et al., 2023a). Mission governance can therefore not assume and expect consensus, but “thrives on the need to identify and work with diversity, dissension and conflicting worldviews” (Schot and Steinmueller, 2018, p. 1564). Policymakers may draw from constructive approaches that aim to create mutual understanding (Cuppen, 2012; Ligtoet et al., 2016). While this is helpful, wicked problems are to some extent irreconcilably contested because disagreement tends to be rooted in fundamentally opposing values and worldviews. As a result, policymakers will have to make decisions, knowing that they will not meet everyone’s preferences (Popa et al., 2021; Scott, 2021). Such wicked circumstances raise questions of what decisions are deemed fair, just, and responsible. Insights from fields like Science and Technology Studies and Ethics of Technology underscore that there is not a one-size-fits-all answer to these matters, and that such principles will need to be carefully considered in each context.

To deal with contestation, reflexive governance is needed to promote collective sensemaking because policymakers rarely “know best” or “act best” when governing missions (Garud and Gehman, 2012; Kirchherr et al., 2023, p. 4; Voß and Bornemann, 2011). They can stimulate both first and second-order reflexive learning by “holding up a mirror” to become aware of their own values and worldviews and that these are not universally held (Stilgoe et al., 2013, p. 1571). First-order reflexivity refers to learning “within boundaries of a value system and background theories” (Van de Poel and Zwart, 2010, p. 180). For instance, policymakers may learn what mission strategy formulations and associated problem-solution configurations help achieve missions most effectively. First-order reflexivity may also refer to the continuous monitoring and evaluation of missions (Penna et al., 2023; Weber and Rohrer, 2012). In second-order reflexive learning, however, underlying assumptions and values are to be challenged (Schuurbiens, 2011). For example, policymakers may reflect on what type of values and epistemologies are reflected in missions, formulations, and strategies. As a result, reflexivity failures could be prevented through the consideration of a broader set of problem understandings and solution pathways (Weber and Rohrer, 2012; Wesseling and Meijerhof, 2023).

To reflexively govern missions under contestation, future research should answer questions such as: how can policymakers identify, describe, and compare divergent views on problem-solution configurations (Wanzenböck et al., 2020)?; how should conflicting ideas surrounding these missions be navigated and reflected upon (Wiarda et al., 2023a)?; how do policymakers make sure that they do not exclude viable alternative problem-solution configurations (Wesseling and Meijerhof, 2023)?; and what approaches enable them to reflect on missions and mission-oriented transitions (Coenen et al., 2023)? We may also ask how mission governance promotes collaborative, organizational, interactive, and social (un)learning (van Mierlo and Beers, 2020) and challenges the status quo (Elzinga et al., 2023). Undeniably, dealing with contestation draws attention to the politics of missions (Janssen et al., 2021), and to how frameworks on fairness, justice and responsibility fit in.

2.4. Responding to intractability with tentative governance

Complexity, uncertainty, and contestation make wicked problems intractable¹ (Head, 2022). As discussed, we do not view this incomprehensibility and unmanageability as a wicked dimension, but rather as a culmination of the other wickedness dimensions. Intractability strongly relates to how situated stakeholders, like policymakers, experience wickedness in their daily work and how they “cannot find meta-positions overlooking or unifying perspectives” (Termeer et al., 2019, p. 175). Intractability commonly leads to ‘non-decisions’ because of impasses (Inghelbrecht et al., 2014), ‘analysis paralysis’ (Conklin, 2012), negligence (Norgrove, 2021), or incumbent strategies that justify business-as-usual (Blythe et al., 2018; Smink et al., 2015). In some cases, this inaction may exacerbate wickedness because it can be seen as favouring the demands of certain stakeholders while disregarding those of others. Moreover, transformative action may be hampered by constraints in their political, social, and legal feasibility. Even if policymakers are responsive, they are facing path-dependencies (David, 1995) and lock-ins that limit agency and create inertia (Arthur, 1989; Unruh, 2000). Policymakers also run the risk of generating misaligned (te Kulve and Rip, 2011), illegitimate (Mena and Palazzo, 2012), maladaptive (Magnan et al., 2016), and ‘irresponsible’ outcomes (Von Schomberg, 2013) in case they inadequately navigate or unsoundly respond to stakeholder values and worldviews (Head, 2019). This is particularly the case once wicked problems are treated as ‘tame’ (Rittel and Webber, 1973) and when societal concerns are neglected in the pursuit of ‘purely’ science-based interventions (Head, 2019).

Scholars hint that mission governance requires continuous interventions (Jentoft and Chuenpagdee, 2009) that aim to ‘manage’, ‘resolve’, and ‘cope with’ wickedness (Head and Xiang, 2016; Xiang, 2013). This procedural perspective is important because wicked problems do not have a ‘stopping rule’ and are continuously changing (Rittel and Webber, 1973). Despite the impression that mission goals can give, there is no moment in which problems can unambiguously be viewed as ‘solved’ by stakeholders. A significant part of governance can therefore better focus on the procedures that help incrementally align policies with society (Metze et al., 2023). Hence, Janssen et al. (2021) portray MOIPs as embedded and evolving coordination devices. Mission governance needs to respond to insights that emerge from aforementioned participatory, anticipatory, and reflexive governance to obtain “a capacity to change shape or direction in response to stakeholder and public values and changing circumstances ... while recognizing the insufficiency of knowledge and control” (Stilgoe et al., 2013, p. 1572). Mission governance thus resonates with the notions of tentative and adaptive governance (c.f., Fisher, 2019; Folke et al., 2005; Kuhlmann et al., 2019) because transformative policies like MOIP embody “a strategy of incremental change with a [long-term] transformative agenda” (Patterson et al., 2017, p. 4). It centers around experimentation and probing and is therefore “a process which is alive and changing as additional learning takes place” (Gilmore and Camillus, 1996, p. 878). Tentative governance can draw from strategic niche management (Kemp et al., 1998) and small wins (Bours et al., 2021; Termeer

and Dewulf, 2019) to incrementally promote, assess, and steer mission-oriented transitions while learning from stakeholder values and changing circumstances.

While such a responsiveness is needed to address wicked problems, it is argued to be a substantially overlooked form of responsibility (Pellizzoni, 2004). We do not yet fully understand how mission governance can foster path-creation (Karnøe and Garud, 2001) to escape lock-ins (Unruh, 2000), path-dependencies (Arthur, 1989; David, 1995), and so on. The notion of responsiveness also raises questions about how mission governance responds to diverse interests (Janssen et al., 2021), fosters alignment (Grillitsch et al., 2019; Metzke et al., 2023), and can promote convergence in light of contestation (Janssen et al., 2023a, 2023b; Wanzenböck et al., 2020). Disagreements likely require policymakers to draw from both constructive and agonistic approaches, with the former approach focusing on bridging stakeholder values through mutual understanding, and with the latter approach intended to make difficult decisions under irreconcilable disagreements (Ligtvoet et al., 2016; Popa et al., 2021). Alternatively, governance could promote multiple pathways that are responsive to a plurality of values and worldviews (Scoones et al., 2015). Such an approach nevertheless runs the risk of inviting policy coordination failures across localities and governance levels (Weber and Rohrer, 2012).

3. Towards responsible mission governance: an integrative framework

Up to now, we have discussed how wickedness dimensions, or challenges, require governance to embody certain responsibilities (e.g., uncertainty demands for forms of anticipation). We have also discussed several governance modes that are dedicated to incorporating these responsibilities (e.g., anticipatory governance promotes anticipation). Table 1 synthesizes these linkages into an integrative framework, also including which outcomes can result from implementing the various governance modes.

As the governance modes largely originate from different debates, little attention has been paid to how they might complement each other. One of the few exceptions is Kivimaa (2022), who discusses how forms of inclusion are helpful in formulating and co-creating visions for the future. Participatory governance thus contributes to anticipatory governance, as pluralistic input helps formulate more inclusive visions for the future. Upon closer inspection, most governance modes have the potential of contributing to multiple wickedness challenges. Table 2 provides an overview of how these modes help to address the wickedness dimension they are originally most associated with (on the diagonal), as well as how they can be relevant for dealing with the other wickedness challenges.

What is more, for truly wicked problems, the complexity, uncertainty, contestation, and subsequent intractability reinforce each other substantially. For instance, complexity implies that causalities between problems, solutions, and impacts are difficult – if not impossible – to foresee, which hence gives rise to uncertainties (Renn et al., 2011). Contestation may follow because stakeholders can disagree on what levels of these uncertainties are deemed acceptable (Taebi et al., 2020). Such illustrative dynamics highlight that wickedness dimensions interact, and that the meaningfulness of a single governance responsibility and governance mode is limited. As a result, policymakers will need to integrate various complementary responsibilities and modes to create a more comprehensive and responsible form of mission governance that is able to meaningfully cope with wickedness dimensions. Although there are abundant studies that implicitly demonstrate that such integration is needed, only rarely are these explicitly combined. Klerkx and Rose (2020) make a similar, but implicit, plea as they argue that “until we articulate inclusive visions of the future, it is difficult to start to anticipate what the impacts of the [mission-oriented] transition will be, and how they can be made more responsible” (p.5). Taking such claims seriously, we draw inspiration from Stilgoe et al. (2013) by suggesting that responsible mission governance entails an integrative and procedural approach to developing, implementing, and evaluating missions that potentially conduce transitions. It embodies the responsibilities of inclusion, anticipation, reflexivity, and responsiveness as a form of mission stewardship to help address wicked problems without disregarding stakeholder values and worldviews. This can be done through the integration of the four governance modes that we have discussed, but we recognize that there are other, yet similar, governance modes that may also do this. We suggest that the responsible mission governance framework could contribute to more desirable transitions, potentially safeguarding principles of fairness, justice, and equity.

4. Responsible mission governance in a multi-level context

In practice, responsible mission governance takes place in a multi-level and multi-scalar context. However, the ways in which missions can be governed responsibly across such levels has largely been neglected (Uyarra et al., 2023). On the one hand, responsibilities and authorities are distributed vertically, across multiple levels of (existing) governance structures (i.e., subnational, national, and supranational; Hooghe and Marks, 2003; Uyarra, 2024; Wanzenböck and Frenken, 2020). On the other hand, wicked problems emerge, evolve, and interact across various scales (Wiarda and Doorn, 2023).

Table 1
An integrative framework for responsible mission governance.

An integrative framework for responsible mission governance			
Challenges	Responsibilities	Modes	Outcomes
Complexity	Inclusion	Participatory governance	Social robustness
Uncertainty	Anticipation	Anticipatory governance	Preparedness
Contestation	Reflexivity	Reflexive governance	Awareness
Intractability	Responsiveness	Tentative governance	Alignment

Table 2
Possible complementarities between governance modes in addressing challenges of wicked problems.

	Responsible mission governance			
	Participatory governance	Anticipatory governance	Reflexive governance	Tentative governance
Complexity	Reaps distributed knowledge, moral judgement, and agency through inclusion	Envisions alternative futures that account for complexity	Challenges assumptions and biases	Experiments with and learns from complexity for socially robust outcomes
Uncertainty	Yields pluralistic ideas about the future	Identifies various futures through anticipation	Unveils alternative, but possible, scenarios	Mitigates and prepares for future scenarios as they are envisioned
Contestation	Generates conflicting values and worldviews	Yields opposing ideas about the future	Creates awareness of disagreement through reflexivity	Adjusts efforts in response to contestation
Intractability	Opens up decision-making	Informs about consequences of possible decisions	Helps take in meta-positions for overlooking perspectives	Responds to insights despite the insufficiency of knowledge and control

It is commonly assumed that wicked problems are best dealt with on high governance levels where economies of scale, complementarities, and vast resources can be found (Uyarra et al., 2023). Nevertheless, high-level, scalable, and standardized approaches generally neglect and obscure context-specific considerations (Pfothenhauer et al., 2022). Regions embody unique values, worldviews, and other considerations, while simultaneously “challenges do not present themselves as the same for every region or nation, as underlying problems affect places in different ways and to different extents” (Wanzenböck and Frenken, 2020, p. 56). Subsequently, there is an increasing awareness of the importance of addressing wicked problems in context-specific ways (Brett et al., 2023; Flanagan et al., 2021; Wanzenböck and Frenken, 2020; Wiarda and Doorn, 2023). For example, drawing on the small wins framework (Termeer and Dewulf, 2019), Bours et al. (2021) observe the importance of ‘small’ bottom-up initiatives for missions that address ‘grand’ societal challenges.

Despite the importance of a context-specific implementation of missions, the formulation of missions tends to occur at high-governance levels (Reid et al., 2023). To foster top/down integration, responsible mission governance will need to formulate missions that can be translated in alignment with a region’s local context (Coenen et al., 2015; Uyarra, 2024). Responsible mission governance may do so by leveraging the boundary object characteristic of missions (Janssen et al., 2023a, 2023b). This means formulating missions that are “plastic enough to adapt to local needs ..., yet robust enough to maintain a common identity across sites.” (Star and Griesemer, 1989, p. 393). Such missions thus promote cross-level translation, communication, and collaboration because they can be viewed and implemented in context-specific ways.

A possible pitfall for place-based approaches to missions is a vertical coordination failure, in which efforts across governance levels are misaligned. For example, strategic high-level debates may not reflect the normative considerations of local settings (Brett et al., 2023). Responsible mission governance could remedy this challenge by reflecting on cross-level relationships to promote synergies. Approaches to responsible mission governance (e.g., deliberations) should therefore be applied and compared across different governance levels to implement multi-level responsibilities in mission-oriented innovation systems (Fisher and Rip, 2013; Wiarda and Doorn, 2023).

In other words, responsible mission governance requires the integration of participatory, anticipatory, reflexive, and tentative modes across levels of governance to respond to stakeholder values and worldviews, without losing sight of lower/higher level governance efforts.

5. Applying the responsible mission governance framework: a vignette

The responsible mission governance framework introduced in Table 1 is the result of reviewing and integrating different strands of literature. While largely conceptual in nature, this analytical work was conducted in the context of various missions that were implemented by the Dutch government. In what follows, Section 4 uses a vignette to illustrate how the framework was implemented and tested in one of these missions.

We will first describe the mission context in which this implementation took place, namely, the Dutch mission ‘Circular construction by 2050’ (Section 5.1). We proceed in Section 5.2 by elaborating how we applied the responsible mission governance framework in this context via a so-called ‘mission-oriented transition assessment’ (MOTA). The focus of the vignette lays on describing how governance responsibilities and modes were implemented in practice. The development of the MOTA approach and the case-specific insights have been reported elsewhere (Coenen et al., 2023). Lastly, we provide a brief reflection on the framework’s implementation, and discuss some of its key strengths and challenges (Section 5.3).

5.1. The mission ‘Circular construction by 2050’

In 2016, the Dutch government launched the mission *Nederland circulair in 2050* (in English: Circular Dutch economy by 2050; Ministerie van Infrastructuur en Waterstaat, 2016). The mission strategy outlined the mission’s boundaries in scope and time, a portfolio of related projects and strategies, an overview of presumably relevant stakeholders, and an envisioned participatory governance approach through a so-called ‘Transition Team’. The strategy report, in which the formal mission was presented, explained

that: “The idea of the circular economy as a fully closed system is a mobilizing ideal image. The use of primary raw materials and the creation of residual streams can probably never be completely avoided” (Ministerie van Infrastructuur en Waterstaat, 2016, p. 13).

As part of this circular economy mission, four priority domains and corresponding sub-missions were introduced. One of these domains includes construction for which the Transition Team Circular Construction advanced the sub-mission ‘Circular construction by 2050’ in 2018 (Transitie team Bouw, 2018). The associated strategy report stated that the construction sector should procure 100 % circular in 2023; reduce its use of virgin resources by 50 % in 2030; ‘work circular’ while reducing its CO₂ emissions by 49 % in 2030; and ‘be circular’ in 2050. The transition agendas published in 2018 formed the starting point for the formal transition efforts. While these overarching agendas were primarily shaped at a national level, the goals and strategies were adopted and operationalized by several public bodies such as municipalities and provinces.

One of the public bodies that is subjected to the mission is Rijkswaterstaat – the executive agency of the Ministry of Infrastructure and Water Management in the Netherlands – and is primarily responsible for the construction and maintenance of infrastructure in the Netherlands. In response to the circular economy mission, Rijkswaterstaat launched various research projects. One of these aimed to provide insights about how to govern and manage a transition that is required for achieving the stated goals. The responsible mission governance framework was illustrated and tested as part of this project.

5.2. Implementing the framework with a mission-oriented transition assessment

Based on our responsible mission governance framework, the MOTA approach was developed specifically as a means to help govern mission-oriented transitions through reflexive and anticipatory deliberations with stakeholders. The approach aims to provide decision-makers with insights that emerge from collective reflections on missions, mission strategies, and on transitions that these missions may conduce, ultimately with the goal of yielding a greater responsiveness to heterogeneous stakeholder values and worldviews. Coenen et al. (2023) defined MOTA as “a collective appraisal of current and future socio-technical changes to inform stakeholders, particularly policymakers, on how to govern missions” (p.1). MOTA is thus largely procedural by nature, and aspires to bring stakeholders together to jointly reflect on missions and anticipate associated futures (e.g., potential impacts and transition barriers). There are a wide variety of ways in which such deliberations can be structured, but in this context we used socio-technical mission scenarios as our objects of reflection. These scenarios were developed on the basis of two recent studies on the Dutch circular construction mission, conducted by Coenen et al. (2022) and Bours et al. (2022). One scenario contained a strong centralized governance approach, while the other scenario presumed a decentralized approach. Each scenario was written in such a way that they emphasized the wickedness of the mission’s problem-solution space.

The MOTA was conducted in April 2023. The two scenarios were introduced in half-day long focus groups with 17 stakeholders linked to the construction mission, including government representatives, researchers, market parties, and consultancies. Two discussion rounds were held, with each round consisting of four discussion groups. In the first discussion round, each group reflected on one of the two scenarios. The discussions focused on identifying possible implications of mission scenarios for the stakeholders themselves, and how they could cope with the potential challenges that are associated with these implications. The groups were subsequently reshuffled for the second discussion round in which both scenarios were compared, and stakeholders were asked to collectively lay out their views on the most desirable short term (0–3 years), medium term (3–10 years), and long term (10+ years) transition steps. The groups were also asked who they deem responsible for these next transition steps.

At the end of the workshop, the discussion outcomes of all groups were compared in one single plenary session. This session moreover discussed the validity and usefulness of the MOTA exercise. Stakeholders were also asked to provide their feedback through an anonymous survey.

5.3. A brief reflection

Although the vignette above does not serve as a robust analysis, it does illustrate how anticipatory and reflexive deliberations with a diverse set of stakeholders can help integrate mission governance responsibilities and modes as presented in Table 1. Besides reflecting on those responsibilities (R) and modes (M), we also address the outcomes (O) they engendered.

MOTA centres around stakeholder deliberations (R: inclusion; M: participatory governance) to appraise missions and mission strategies (R: reflexivity; M: reflexive governance) and to explore possible futures, for example impacts and transitions barriers (R: anticipation; M: anticipatory governance). Although, unsurprisingly, the MOTA did not result in consensus on the problem definition and the most desirable solution pathway, it did help converge this problem-solution space, and resulted in several concrete to-be-taken actions (O: social robustness; O: awareness). For instance, many groups concluded that standardization efforts are needed to harmonize the notion of circularity before investments can be made and radical actions can be taken. The discussions also helped identify various current and future transition barriers (O: preparedness; O: awareness).

However, the MOTA also revealed some serious challenges. In bringing stakeholders together, we tried to assemble a diverse set of stakeholder representatives. It proved difficult to include civil society organizations and NGOs because very few of them were interested or able to partake in the MOTA exercise. As a result, not all stakeholders were represented (R: inclusion; M: participatory governance).

In addition, discussions revealed conflicting visions for the transition, with different ideas emerging regarding who should bear certain responsibilities, who holds power, and what political views are most helpful in the context of the mission. These discussions also demonstrated how minority views were occasionally regarded as irrelevant or irrational by others, hence disregarding certain perspectives and underlying values. This dynamic suggests that the act of stakeholder inclusion, and especially the act of reflection,

requires more than then the mere inclusion of stakeholders in the physical sense (R: reflexivity; M: reflexive governance).

Stakeholder groups were asked to plan desirable transition steps for the short, medium, and long term. In doing so, the participants often claimed to take a back-casting approach by using the mission goal as an entry point. However, high degrees of uncertainty nearly always forced them to start this planning process with short term actions, demonstrating how difficult it is for stakeholders to foresee futures (R: anticipation; M: anticipatory governance).

Perhaps most crucial of all, although insights were provided to Rijkswaterstaat, it is unclear if, and to what extent, the insights of the MOTA-based dialogues are taken up by policymakers. This raises serious questions about whether participatory, anticipatory, and reflexive forms of governance actually feed into tentative actions that aim to align missions with stakeholder values and worldviews (R: responsiveness; M: tentative governance).

6. Proposing a research agenda for responsible mission governance

Our framework for responsible mission governance opens up new directions for future research (Table 3). While the governance challenges, responsibilities, modes, and outcomes are extensively taken up in academia and even form dedicated research fields on themselves, their integrated application and validity in the context of mission governance requires further investigation because responsible mission governance certainly come with challenges as illustrated by our vignette on the Dutch ‘Circular construction by 2050’ mission.

For example, we speculate that there may be a tension between the urgency of wicked problems (Lazarus, 2009; Levin et al., 2012) and the time-consuming nature of participatory governance (Wang and Lo, 2021) and reflexive governance (Steen, 2021). Participatory governance may furthermore obscure the division of moral labor, potentially leading to organized irresponsibility (Beck, 1992). Understanding such tensions requires empirical research that studies integrative forms of responsible mission governance in practice.

A number of (emerging) approaches offer a promising point of departure. For instance, Sustainability Foresight (Truffer et al., 2008; Voß et al., 2006), MOTA (Coenen et al., 2023), and the TransMission approach (Simons et al., 2023) deploy anticipatory and reflexive deliberations that can inform policymakers on how to govern (mission-oriented) transitions. Our MOTA, as illustrated above, provided various valuable insights that stakeholders believe should be taken up by policymakers. However, it remains unclear to what extent this has actually been the case. In accordance with our framework, we therefore ask whether such approaches to responsible mission governance contribute to more effective and desirable outcomes. More generally, we ask who is included and excluded in mission governance?; how are pluralities of mission outcomes foreseen, defined, and evaluated?; how do policymakers deal with contested problem understandings and solution pathways?; and how should policymakers respond to new and conflicting insights?

Table 3

A research agenda for responsible mission governance.

Challenges	Premises	Research questions
Complexity	Dealing with complexity requires participatory mission governance to explore stakeholder values and worldviews for socially robust outcomes.	<ul style="list-style-type: none"> Who is included and excluded in mission-oriented innovation? How do deliberate forums and hybrid spaces (e.g., mission arenas) help democratize mission-oriented transitions? How are closing mechanisms and power imbalances used to exclude stakeholders?
Uncertainty	Uncertainty warrants anticipatory mission governance to identify, manage, and prepare for (un)desirable impacts.	<ul style="list-style-type: none"> How are possible, probable, and desirable impacts of missions defined, foreseen, and evaluated? How do utopian and dystopian visions of the future influence transitions in the present?
Contestation	Contestation calls for reflexive mission governance to yield awareness of stakeholder values and worldviews and to identify viable alternative problem understandings and solution pathways.	<ul style="list-style-type: none"> How can policymakers identify, compare, and describe divergent views on problem-solution configurations? How should conflicting ideas surrounding missions be navigated and reflected upon? How do policymakers ensure that they do not exclude any viable alternative problem-solution configurations? What approaches enable policymakers to reflect on their own values and worldviews?
Intractability	Intractability demands for tentative mission governance to respond to participatory, anticipatory, and reflexive governance insights.	<ul style="list-style-type: none"> How can policymakers align and converge values and worldviews of stakeholders? How can policymakers foster collective action while leaving room for polycentric responses that are sensitive to localities of ‘grand societal challenges’? How are undesirable impacts prevented, mitigated, and/or adapted to?
How to integrate governance responsibilities and modes?	Combined forms of participatory, anticipatory, reflexive, and tentative governance are necessary to cope with wickedness responsibly.	<ul style="list-style-type: none"> How do governance responsibilities and modes interact? What approaches/instruments integrate the various mission governance responsibilities and modes? What are the roles of anticipatory and reflexive deliberations in mission-oriented transitions? How can responsible mission governance by different authorities be coordinated in a multi-level context?

We would also like to stress the non-exclusive and non-exhaustive nature of the proposed framework. For example, while participatory governance may help cope with complexity, there are other governance modes that are likewise helpful for this challenge, such as collaborative and network governance (Ansell and Gash, 2008; Sørensen and Torfing, 2009). Our framework is therefore not meant as a rigid conceptualization, but rather as a guiding frame that emphasizes the underlying governance responsibilities that are needed to address wickedness challenges, e.g., the responsibility of ‘inclusion’ needed to deal with the challenge of ‘complexity’. Future contributions could also identify additional governance challenges, responsibilities, modes, and outcomes improve the effectiveness and desirability of mission governance. For instance, backwards-looking forms of responsibility, like transparency, may arguably lead to more accountable and trustworthy decision-making and could therefore be an interesting point of departure. Follow-up research could also consider the need for certain capabilities and institutions in promoting responsible mission governance. Authors have argued that the effectiveness of missions largely dependent on the government’s ability to develop certain capabilities, e.g., bottom-up engagement to “leave enough space for contestation and adaptability” in developing, implementing, and evaluating missions (Kattel and Mazzucato, 2018, p. 797). To what extent these capabilities can be developed requires more insights in, for instance, the possibilities and constraints found in the policy system in which policymakers operate (Braams et al., 2021).

7. Concluding remarks

In this paper, we have discussed how the uptake of MOIP, as a procedural means to address wicked problems, calls for an explicit scrutiny of governance responsibilities and governance modes that are needed to better cope with the complexity, uncertainty, contestation, and the subsequent intractability associated with these wicked problems. Although we used wickedness as our entry point, we coupled insights from various other traditions, notably sustainability transitions, innovation policy, and responsible innovation for the conceptualization of our framework. This framework was primarily designed to promote more desirable transitions. In addition to developing and briefly illustrating this provisional and integrative framework, we have provided a research agenda with the aim of opening up the debate on responsible mission governance. We advocate future research on the validity and usefulness of our work because this may prevent the common pitfall of assuming that novel approaches like ours can meaningfully address wicked problems (Termeer et al., 2019). We also draw attention to the non-exclusive and non-exhaustive nature of our framework, as other dimensions may be of importance as well. For example, the role of backward-looking forms of responsibility like transparency could be a promising point of departure. In addition, developing appropriate capabilities and institutions could support responsible mission governance. To conclude, we call for a better understanding of responsible mission governance, in particular of the governance challenges, responsibilities, modes, and outcomes that are relevant for promoting more effective and desirable missions.

CRedit authorship contribution statement

Martijn Wiarda: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Conceptualization. **Matthijs J. Janssen:** Writing – review & editing, Writing – original draft, Conceptualization. **Tom B.J. Coenen:** Writing – review & editing, Methodology, Formal analysis, Data curation. **Neelke Doorn:** Writing – review & editing, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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References

- Anderson, E., 1993. *Value in Ethics and Economics*. Harvard University Press, Cambridge, MA.
- Ansell, C., Gash, A., 2008. Collaborative governance in theory and practice. *J. Public Adm. Res. Theory* 18, 543–571. <https://doi.org/10.1093/jopart/mum032>.
- Arnstein, S.R., 1969. A Ladder Of Citizen Participation. *J. Am. Inst. Plann.* 35, 216–224.
- Arthur, B., 1989. Competing technologies, increasing returns, and lock-in by historical events. *Econ. J.* 99, 116–131.
- Balanzó, A., Mónica, G., Mejía, R., 2023. Towards epistemic diversity in sustainability transitions : an exploration of hybrid socio - technical systems. *Sustain. Sci.* 18, 2511–2531. <https://doi.org/10.1007/s11625-023-01370-9>.

- Bali, A.S., Howlett, M., Lewis, J.M., Ramesh, M., 2021. Procedural policy tools in theory and practice. *Policy Soc.* 40, 295–311. <https://doi.org/10.1080/14494035.2021.1965379>.
- Beck, U., 1992. Towards a new modernity. *Risk Society*. SAGE Publications, London. <https://doi.org/10.2307/143601>.
- Blythe, J., Silver, J., Evans, L., Armitage, D., Bennett, N.J., Moore, M.L., Morrison, T.H., Brown, K., 2018. The dark side of transformation: latent risks in contemporary sustainability discourse. *Antipode* 50, 1206–1223. <https://doi.org/10.1111/anti.12405>.
- Bommel, S., Van, Aarts, N., Turnhout, E., 2009. Social learning for solving complex problems: a promising solution or wishful thinking? A case study of multi-actor negotiation for the integrated management and sustainable use of the Drentsche AA area in the Netherlands. *Environ. Policy Gov.* 19, 400–412. <https://doi.org/10.1002/eet.526>.
- Börjesona, L., Höjer, M., Dreborg, K.-H., Ekvall, T., Finnveden, G., 2006. Scenario types and techniques: towards a user's guide. *Futures* 38, 723–739. <https://doi.org/10.1016/j.futures.2005.12.002>.
- Bours, S., Swartjes, J., Hekkert, M., 2022. Transitie naar een circulaire grond-, weg- en waterbouw - Een missie-gedreven innovatie systeem analyse.
- Bours, S.A.M.J.V., Wanzenböck, I., Frenken, K., 2021. Small wins for grand challenges . A bottom-up governance approach to regional innovation policy. *Eur. Plan. Stud.* 0, 1–28. <https://doi.org/10.1080/09654313.2021.1980502>.
- Braams, R.B., Wesseling, J.H., Meijer, A.J., Hekkert, M.P., 2021. Legitimizing transformative government: aligning essential government tasks from transition literature with normative arguments about legitimacy from Public Administration traditions. *Environ. Innov. Soc. Trans.* 39, 191–205. <https://doi.org/10.1016/j.eist.2021.04.004>.
- Brett, N., Magnusson, T., Andersson, H., 2023. From global climate goals to local practice—mission-oriented policy enactment in three Swedish regions. *Sci. Public Policy*. <https://doi.org/10.1093/scipol/scad010>.
- Buur, J., Matthews, B., 2008. Participatory innovation. *Int. J. Innov. Manag.* 12, 255–273. <https://doi.org/10.1142/S1363919608001996>.
- Callon, M., Lascoumes, P., Barthe, Y., 2009. *Acting in an Uncertain World: research methods. An essay on technical democracy.* The MIT Press, Cambridge, MA.
- Cameron, E., Mearns, R., McGrath, J.T., 2015. Translating climate change: adaptation, resilience, and climate politics in Nunavut, Canada. *Ann. Assoc. Am. Geogr.* 105, 274–283. <https://doi.org/10.1080/00045608.2014.973006>.
- Chesbrough, H., 2003. *Open Innovation. Harvard business school press, Boston.*
- Chilvers, J., Pallett, H., Hargreaves, T., 2018. Ecologies of participation in socio-technical change: the case of energy system transitions. *Energy Res. Soc. Sci.* 42, 199–210. <https://doi.org/10.1016/j.erss.2018.03.020>.
- Churchman, C.W., 1967. Wicked problems. *Manag. Sci.* 14, 141–146.
- Coenen, L., Hansen, T., Rekers, J.V., 2015. Innovation policy for grand challenges. An economic geography perspective. *Geogr. Compass* 9, 483–496. <https://doi.org/10.1111/gec3.12231>.
- Coenen, T.B.J., Visscher, K., Volker, L., 2022. A systemic perspective on transition barriers to a circular infrastructure sector. *Constr. Manag. Econ.* 41, 22–43. <https://doi.org/10.1080/01446193.2022.2151024>.
- Coenen, T.B.J., Wiarda, M., Visscher, K., Penna, C., Volker, L., 2023. Mission-Oriented Transition Assessment.
- Collingridge, D., 1980. *The Social Control of Technology.* St. Martin's Press, New York.
- Conklin, J., 2012. Wicked problems and social complexity. *Dialogue Mapping: Building Shared Understanding of Wicked Problems.* John Wiley & Sons Inc, pp. 1–25. <https://doi.org/10.1201/b13086-7>.
- Cuppen, E., 2012. Diversity and constructive conflict in stakeholder dialogue: considerations for design and methods. *Policy Sci.* 45, 23–46. <https://doi.org/10.1007/s11077-011-9141-7>.
- David, P., 1995. Clio and the economics of QWERTY. In: *Ninety-Seventh Annual Meeting of the American Economic Association*, pp. 332–337.
- Dery, D., 1984. *Problem Definition in Policy Analysis.* University Press of Kansas.
- Elzinga, R., Janssen, M.J., Wesseling, J., Negro, S.O., Hekkert, M.P., 2023. Assessing mission-specific innovation systems: towards an analytical framework. *Environ. Innov. Soc. Trans.* 48, 100745. <https://doi.org/10.1016/j.eist.2023.100745>.
- Eriksen, S., Schipper, E.L.F., Scoville-Simonds, M., Vincent, K., Adam, H.N., Brooks, N., Harding, B., Khatri, D., Lenaerts, L., Liverman, D., Mills-Novoa, M., Mosberg, M., Movik, S., Muok, B., Nightingale, A., Ojha, H., Sygna, L., Taylor, M., Vogel, C., West, J.J., 2021. Adaptation interventions and their effect on vulnerability in developing countries: help, hindrance or irrelevance? *World Dev.* 141, 105383. <https://doi.org/10.1016/j.worlddev.2020.105383>.
- European Commission, 2022. *European missions. Climate-neutral and Smart Cities by 2030. Implementation Planning, Research and Innovation, Brussels.*
- Farrell, R., Hooker, C., 2013. Design, science and wicked problems. *Des. Stud.* 34, 681–705. <https://doi.org/10.1016/j.destud.2013.05.001>.
- Ferraro, F., Etzion, D., Gehman, J., 2015. Tackling grand challenges pragmatically: robust action revisited. *Organ. Stud.* 36, 363–390. <https://doi.org/10.1177/0170840614563742>.
- Fisher, E., 2019. Governing with ambivalence: the tentative origins of socio-technical integration. *Res. Policy* 48, 1138–1149. <https://doi.org/10.1016/j.respol.2019.01.010>.
- Fisher, E., Rip, A., 2013. Responsible Innovation: Multi-Level Dynamics and Soft Intervention Practices. In: Owen, R., Bessant, J., Heintz, M. (Eds.), *Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society.* John Wiley & Sons, Ltd, pp. 165–183.
- Flanagan, K., Uyarra, E., Wanzenböck, I., 2021. Towards a problem-oriented regional industrial policy: possibilities for public intervention in framing, valuation and market creation. *Reg. Stud.*
- Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. *Annu. Rev. Environ. Resour.* 30, 441–473. <https://doi.org/10.1146/annurev.energy.30.050504.144511>.
- Friedman, B., Kahn Jr., P.H., Borning, A., 2006. Value sensitive design and information systems: three case studies. In: Zhang, P., Galetta, D. (Eds.), *Human-Computer Interaction and Management Information Systems: Foundations.* M.E. Sharpe, Inc, New York.
- Garud, R., Gehman, J., 2012. Metatheoretical perspectives on sustainability journeys: evolutionary, relational and durational. *Res. Policy* 41, 980–995. <https://doi.org/10.1016/j.respol.2011.07.009>.
- Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Res. Policy* 31, 1257–1274.
- Geels, F.W., Schot, J., 2007. Typology of sociotechnical transition pathways. *Res. Policy* 36, 399–417. <https://doi.org/10.1016/j.respol.2007.01.003>.
- Genus, A., Stirling, A., 2018. Collingridge and the dilemma of control: towards responsible and accountable innovation. *Res. Policy* 47, 61–69. <https://doi.org/10.1016/j.respol.2017.09.012>.
- Gilmore, W.S., Camillus, J.C., 1996. Do your planning processes meet the reality test? *Long Range Plann.* 29, 869–879. [https://doi.org/10.1016/S0024-6301\(97\)82824-5](https://doi.org/10.1016/S0024-6301(97)82824-5).
- Grillitsch, M., Hansen, T., Coenen, L., Miörner, J., Moodysson, J., 2019. Innovation policy for system-wide transformation: the case of strategic innovation programmes (SIPs) in Sweden. *Res. Policy* 48, 1048–1061. <https://doi.org/10.1016/j.respol.2018.10.004>.
- Grin, J., Grunwald, A., 2000. *Vision Assessment: Shaping Technology in 21st Century Society.* Springer.
- Guston, D.H., 2014. Understanding “anticipatory governance. *Soc. Stud. Sci.* 44, 218–242. <https://doi.org/10.1177/0306312713508669>.
- Guston, D.H., Sarewitz, D., 2002. Real-time technology assessment. *Technol. Soc.* 24, 93–109. [https://doi.org/10.1016/S0160-791X\(01\)00047-1](https://doi.org/10.1016/S0160-791X(01)00047-1).
- Hajer, M., 2003. Policy without polity? Policy analysis and the institutional void. *Policy Sci.* 36, 175–195. <https://doi.org/10.1023/A:1024834510939>.
- Hansson, S.O., 2009. From the casino to the jungle: dealing with uncertainty in technological risk management. *Synthese* 168, 423–432. <https://doi.org/10.1007/s11229-008-9444-1>.
- Head, B.W., 2022. *Wicked Problems in Public policy: Understanding and Responding to Complex Challenges.* Wicked Problems in Public Policy.
- Head, B.W., 2019. Forty years of wicked problems literature : forging closer links to policy studies. *Policy Soc.* 38, 180–197. <https://doi.org/10.1080/14494035.2018.1488797>.
- Head, B.W., 2008. Wicked problems in public policy. *Public Policy* 3, 101–118.
- Head, B.W., Xiang, W., 2016. Landscape and Urban Planning Why is an APT approach to wicked problems important? *Landsc. Urban Plan.* 154, 4–7. <https://doi.org/10.1016/j.landurbplan.2016.03.018>.

- Hekkert, M.P., Janssen, M.J., Wesseling, J.H., Negro, S.O., 2020. Mission-oriented innovation systems. *Environ. Innov. Soc. Trans.* 34, 76–79. <https://doi.org/10.1016/j.eist.2019.11.011>.
- Hoffmann-Riem, H., Wynne, B., 2002. In risk assessment, one has to admit ignorance. *Nature* 416, 123. <https://doi.org/10.1038/416123a>.
- Hooghe, L., Marks, G., 2003. Unraveling the central state, but how? Types of multi-level governance. *Am. Polit. Sci. Rev.* 97, 61–71. <https://doi.org/10.4324/9781315254234-12>.
- Hoppe, R., 2011. *The Governance of Problems: Puzzling, Powering and Participation*. Policy Press, Bristol.
- Inghelbrecht, L., Dessein, J., Van Huylenbroeck, G., 2014. The non-GM crop regime in the EU: how do Industries deal with this wicked problem? *NJAS - Wageningen J. Life Sci.* 70, 103–112. <https://doi.org/10.1016/j.njas.2014.02.002>.
- Janssen, M.J., Torrens, J., Wesseling, J.H., 2021. The promises and premises of mission-oriented innovation policy - a reflection and ways forward. *Sci. Public Policy*. <https://doi.org/10.1093/scipol/scaa072>.
- Janssen, M.J., Wesseling, J., Torrens, J., Weber, M., Penna, C., Klerkx, L., 2023a. Missions as boundary objects for transformative change: understanding coordination across policy, research and stakeholder communities. *Sci. Public Policy* 00, 1–18.
- Janssen, M.J., Wesseling, J.H., Torrens, J., Weber, K.M., Penna, C., Klerkx, L., 2023b. Mission as a boundary objects for transformative change: understanding coordination across policy, research, and stakeholder communities. *Sci. Public Policy* scac080.
- Jentoft, S., Chuenpagdee, R., 2009. Fisheries and coastal governance as a wicked problem. *Mar. Policy* 33, 553–560. <https://doi.org/10.1016/j.marpol.2008.12.002>.
- Kaplan, L.R., Faroouque, M., Sarewitz, D., Tomblin, D., 2021. Designing participatory technology assessments: a reflexive method for advancing the public role in science policy decision-making. *Technol. Forecast. Soc. Change* 171, 120974. <https://doi.org/10.1016/j.techfore.2021.120974>.
- Karnøe, P., Garud, R., 2001. Path creation as a process of mindful deviation. In: Garud, R., Karnøe, P. (Eds.), *Path Dependence and Creation*. Lawrence Earlbaum Associates.
- Kattel, R., Mazzucato, M., 2018. Mission-oriented innovation policy and dynamic capabilities in the public sector. *Ind. Corp. Chang.* 27, 787–801. <https://doi.org/10.1093/icc/dty032>.
- Kemp, R., Schot, J., Hoogma, R., 1998. Regime shifts to sustainability through processes of niche formation : the approach of strategic niche management. *Technol. Anal. Strateg. Manag.* 10, 175–198. <https://doi.org/10.1080/09537329808524310>.
- Kirchherr, J., Hartley, K., Tukker, A., 2023. Missions and mission-oriented innovation policy for sustainability : a review and critical reflection. *Environ. Innov. Soc. Trans.* 47, 100721 <https://doi.org/10.1016/j.eist.2023.100721>.
- Kivimaa, P., 2022. Transforming innovation policy in the context of global security. *Environ. Innov. Soc. Trans.* 43, 55–61. <https://doi.org/10.1016/j.eist.2022.03.005>.
- Klerkx, L., Rose, D., 2020. Dealing with the game-changing technologies of Agriculture 4.0: how do we manage diversity and responsibility in food system transition pathways? *Glob. Food Sec.* 24, 100347 <https://doi.org/10.1016/j.gfs.2019.100347>.
- Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wiecek, A., Alkemade, F., Avelino, F., Bergek, A., Boons, F., Fünfschilling, L., Hess, D., Holtz, G., Hyysalo, S., Jenkins, K., Kivimaa, P., Martiskainen, M., McMeekin, A., Mühlemeier, M.S., Nykvist, B., Pel, B., Raven, R., Rohracher, H., Sandén, B., Schot, J., Sovacool, B., Turnheim, B., Welch, D., Wells, P., 2019. An agenda for sustainability transitions research: state of the art and future directions. *Environ. Innov. Soc. Trans.* 31, 1–32. <https://doi.org/10.1016/j.eist.2019.01.004>.
- Kok, K.P.W., Klerkx, L., 2023. Addressing the politics of mission-oriented agricultural innovation systems. *Agric. Syst.* 211, 103747 <https://doi.org/10.1016/j.agsy.2023.103747>.
- Kostoff, R.N., Schaller, R.R., 2001. Science and technology roadmaps. *IEEE Trans. Eng. Manag.* 48, 132–143. <https://doi.org/10.1109/17.922473>.
- Kuhlmann, S., Stegmaier, P., Konrad, K., 2019. The tentative governance of emerging science and technology—a conceptual introduction. *Res. Policy* 48, 1091–1097. <https://doi.org/10.1016/j.respol.2019.01.006>.
- Kuk, G., Faik, I., Janssen, M., 2023. Editorial technology assessment for addressing grand societal challenges. *IEEE Trans. Eng. Manag.* 70, 1055–1060. <https://doi.org/10.1109/TEM.2022.3233460>.
- Larrue, P., 2021. The design and implementation of mission-oriented innovation policies: a systemic policy approach to address societal challenges. *OECD Sci. Technol. Ind. Policy Pap.* 1–22.
- Lazarus, R.J., 2009. Super wicked problems and climate change: restraining the present to liberate the future. *Cornell Law Rev.* 94, 1153–1233.
- Lennon, M., 2017. Decolonizing energy: black lives matter and technoscientific expertise amid solar transitions. *Energy Res. Soc. Sci.* 30, 18–27. <https://doi.org/10.1016/j.erss.2017.06.002>.
- Levin, K., Cashore, B., Bernstein, S., Auld, G., 2012. Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change. *Policy Sci.* 45, 123–152. <https://doi.org/10.1007/s11077-012-9151-0>.
- Ligtvoet, A., Cuppen, E., Di Ruggero, O., Hemmes, K., Pesch, U., Quist, J., Mehos, D., 2016. New future perspectives through constructive conflict: exploring the future of gas in the Netherlands. *Futures* 78–79, 19–33. <https://doi.org/10.1016/j.futures.2016.03.008>.
- Macnaghten, P., Owen, R., Stilgoe, J., Wynne, B., Azevedo, A., de Campos, A., Chilvers, J., Dagnino, R., di Giulio, G., Frow, E., Garvey, B., Groves, C., Hartley, S., Knobel, M., Kobayashi, E., Lehtonen, M., Lezaun, J., Mello, L., Monteiro, M., Pamplona da Costa, J., Rigolin, C., Rondani, B., Staykova, M., Taddei, R., Till, C., Tyfield, D., Wilford, S., Velho, L., 2014. Responsible innovation across borders: tensions, paradoxes and possibilities. *J. Responsible Innov.* 1, 191–199. <https://doi.org/10.1080/23299460.2014.922249>.
- Magnan, A.K., Schipper, E.L.F., Burkett, M., Bharwani, S., Burton, I., Eriksen, S., Gemenne, F., Schaar, J., Ziervogel, G., 2016. Addressing the risk of maladaptation to climate change. *Wiley Interdiscip. Rev. Clim. Chang.* 7, 646–665. <https://doi.org/10.1002/wcc.409>.
- Mazzucato, M., 2018. Mission-oriented innovation policies: challenges and opportunities. *Ind. Corp. Chang.* 27, 803–815. <https://doi.org/10.1093/icc/dty034>.
- Mena, S., Palazzo, G., 2012. Input and output legitimacy of multi-stakeholder initiatives. *Bus. Ethics Q.* 22, 527–556. <https://doi.org/10.5840/beq201222333>.
- Metze, T.A.P., van den Broek, J., van Est, R., Cuppen, E.H.W.J., 2023. Participatory repertoires for aligning policy and society: an analysis of Dutch stakeholder views on deep geothermal energy. *Energy Res. Soc. Sci.* 98, 103019 <https://doi.org/10.1016/j.erss.2023.103019>.
- Ministerie van Infrastructuur en Waterstaat, 2016. *A Circular Economy in the Netherlands by 2050*. Den Haag.
- Moglia, M., Frantzeskaki, N., Newton, P., Pineda-Pinto, M., Witheridge, J., Cook, S., Glackin, S., 2021. Accelerating a green recovery of cities: lessons from a scoping review and a proposal for mission-oriented recovery towards post-pandemic urban resilience. *Dev. Built Environ.* 7, 100052 <https://doi.org/10.1016/j.dibe.2021.100052>.
- Morrison, T.H., Adger, W.N., Brown, K., Lemos, M.C., Huitema, D., Hughes, T.P., 2017. Mitigation and adaptation in polycentric systems: sources of power in the pursuit of collective goals. *Wiley Interdiscip. Rev. Clim. Chang.* 8, 1–16. <https://doi.org/10.1002/wcc.479>.
- Mueller, M., Schlaile, M.P., Lang, S., Janssen, M.J., Bogner, K., Wanzenböck, I., Schramm, M., Pyka, A., Mueller, M., Schlaile, M.P., 2023. Developing adequate innovation policy heuristics for addressing grand societal challenges : making sense of wickedness.
- Muttitt, G., Kartha, S., 2020. Equity, climate justice and fossil fuel extraction: principles for a managed phase out. *Clim. Policy* 1024–1042. <https://doi.org/10.1080/14693062.2020.1763900>.
- Nelson, J.P., Selin, C.L., Scott, C.T., 2021. Toward anticipatory governance of human genome editing: a critical review of scholarly governance discourse. *J. Responsible Innov.* 0, 1–39. <https://doi.org/10.1080/23299460.2021.1957579>.
- Newig, J., Fritsch, O., 2009. Participatory governance and sustainability. Findings of a meta-analysis of stakeholder involvement in environmental decision-making. *Reflexive Governance in the Public Interest*. MIT Press, pp. 1–28.
- Norgrove, D.J., 2021. Drug Development During COVID-19: A Proximity Approach to Tackling the World's Most Wicked Problem. The University of Auckland.
- Nowotny, H., 2003. Democratizing expertise and socially robust knowledge. *Sci. Public Policy* 30, 151–156. <https://doi.org/10.3152/147154303781780461>.
- Olsson, R., 2007. In search of opportunity management: is the risk management process enough? *Int. J. Proj. Manag.* 25, 745–752. <https://doi.org/10.1016/j.ijproman.2007.03.005>.
- Patterson, J., Schulz, K., Vervoort, J., van der Hel, S., Widerberg, O., Adler, C., Hurlbert, M., Anderton, K., Sethi, M., Barau, A., 2017. Exploring the governance and politics of transformations towards sustainability. *Environ. Innov. Soc. Trans.* 24, 1–16. <https://doi.org/10.1016/j.eist.2016.09.001>.

- Pellizzoni, L., 2004. Responsibility and environmental governance. *Env. Polit.* 13, 541–565. <https://doi.org/10.1080/0964401042000229034>.
- Penna, C.C.R., Romero Goyeneche, O.Y., Matti, C., 2023. Exploring indicators for monitoring sociotechnical system transitions through portfolio networks. *Sci. Public Policy* 1–23. <https://doi.org/10.1093/scipol/scad015>.
- Pesch, U., Vermaas, P.E., 2020. The wickedness of Rittel and Webber's dilemmas. *Adm. Soc.* 52, 960–979. <https://doi.org/10.1177/0095399720934010>.
- Pfotenhauer, S., Laurent, B., Papageorgiou, K., Stilgoe, J., 2022. The politics of scaling. *Soc. Stud. Sci.* 52, 3–34.
- Pidgeon, N., Parkhill, K., Corner, A., Vaughan, N., 2013. Deliberating stratospheric aerosols for climate geoengineering and the SPICE project. *Nat. Clim. Chang.* 3, 451–457. <https://doi.org/10.1038/nclimate1807>.
- Popa, E.O., Blok, V., Wesselink, R., 2021. An agonistic approach to technological conflict. *Philos. Technol.* 34, 717–737. <https://doi.org/10.1007/s13347-020-00430-7>.
- Rabadjjeva, M., Terstriep, J., 2021. Ambition meets reality: mission-oriented innovation policy as a driver for participative governance. *Sustainability* 13, 1–23.
- Reid, A., Steward, F., Miedzinski, M., 2023. Aligning smart specialisation with transformative innovation policy. *Luxembourg*. 10.2760/359295.
- Renn, O., Klinke, A., Van Asselt, M., 2011. Coping with complexity, uncertainty and ambiguity in risk governance: a synthesis. *Ambio* 40, 231–246. <https://doi.org/10.1007/s13280-010-0134-0>.
- Ritala, P., 2023. Grand challenges and platform ecosystems : scaling solutions for wicked ecological and societal problems. *J. Prod. Innov. Manag.* 1–16. <https://doi.org/10.1111/jpim.12682>.
- Rittel, H., Webber, M., 1973. Dilemmas in a general theory of planning. *Policy Sci* 4, 155–196. <https://doi.org/10.1080/01636609209550084>.
- Robinson, D.K.R., 2009. Co-evolutionary scenarios: an application to prospecting futures of the responsible development of nanotechnology. *Technol. Forecast. Soc. Change* 76, 1222–1239. <https://doi.org/10.1016/j.techfore.2009.07.015>.
- Roßmann, M., 2021. Vision as make-believe: how narratives and models represent sociotechnical futures. *J. Responsible Innov.* 8, 70–93. <https://doi.org/10.1080/23299460.2020.1853395>.
- Rowe, G., Frewer, L.J., 2005. A typology of public engagement mechanisms. *Sci. Technol. Hum. Values* 30, 251–290. <https://doi.org/10.1177/01622439004271724>.
- Rowe, G., Frewer, L.J., 2000. Public participation methods: a framework for evaluation. *Sci. Technol. Hum. Values* 25, 3–29. <https://doi.org/10.1177/016224390002500101>.
- Schot, J., Rip, A., 1997. The past and future of constructive technology assessment. *Technol. Forecast. Soc. Change* 54, 251–268. [https://doi.org/10.1016/s0040-1625\(96\)00180-1](https://doi.org/10.1016/s0040-1625(96)00180-1).
- Schot, J., Steinmueller, W.E., 2018. Three frames for innovation policy: R&D, systems of innovation and transformative change. *Res. Policy* 47, 1554–1567. <https://doi.org/10.1016/j.respol.2018.08.011>.
- Schumpeter, J., 1934. *The Theory of Economic Development*. Springer, Boston.
- Schuurbiens, D., 2011. What happens in the Lab: applying midstream modulation to enhance critical reflection in the laboratory. *Sci. Eng. Ethics* 17, 769–788. <https://doi.org/10.1007/s11948-011-9317-8>.
- Scoones, I., Leach, M., Newell, P., 2015. *The Politics of Green Transformations, The Politics of Green Transformations*. Routledge.
- Scott, D., 2021. Diversifying the deliberative turn: toward an agonistic RRI. *Sci. Technol. Hum. Values* 46, 1067–1087. <https://doi.org/10.1177/01622439211067268>.
- Selin, C., 2011. Negotiating plausibility: intervening in the future of nanotechnology. *Sci. Eng. Ethics* 17, 723–737. <https://doi.org/10.1007/s11948-011-9315-x>.
- Seyfang, G., Smith, A., 2007. Grassroots innovations for sustainable development: towards a new research and policy agenda. *Environ. Polit.* 16, 584–603. <https://doi.org/10.1080/09644010701419121>.
- Sharma, A., Banerjee, R., 2021. Framework to analyze the spatial distribution of the labor impacts of clean energy transitions. *Energy Policy* 150, 112158. <https://doi.org/10.1016/j.enpol.2021.112158>.
- Simons, L., Nijhof, A., Janssen, M., 2023. TransMission: the mission-driven transition approach to managing complex change processes.
- Smink, M.M., Hekkert, M.P., Negro, S.O., 2015. Keeping sustainable innovation on a leash? Exploring incumbents institutional strategies. *Bus. Strateg. Environ.* 24, 86–101. <https://doi.org/10.1002/bse.1808>.
- Smith, A., Stirling, A., 2010. *The politics of social-ecological resilience and sustainable socio-technical transitions*. *Ecol. Soc.* 15.
- Snowden, D., Rancati, A., 2021. Managing complexity (and chaos) in times of crisis. *Luxembourg*.
- Sørensen, E., Torfing, J., 2009. Making governance networks effective and democratic through metagovernance. *Public Adm.* 87, 234–258. <https://doi.org/10.1111/j.1467-9299.2009.01753.x>.
- Stahl, B.C., McBride, N., Wakunuma, K., Flick, C., 2014. The empathic care robot: a prototype of responsible research and innovation. *Technol. Forecast. Soc. Change* 84, 74–85. <https://doi.org/10.1016/j.techfore.2013.08.001>.
- Star, S.L., Griesemer, J.R., 1989. Institutional ecology, “translation” and boundary objects: amateurs and professionals in Berkeley's museum of vertebrate zoology, 1907–39. *Soc. Sci. Inf.* 19, 387–420.
- Steen, M., 2021. Slow innovation: the need for reflexivity in responsible innovation (RI). *J. Responsible Innov.* 0, 1–7. <https://doi.org/10.1080/23299460.2021.1904346>.
- Stilgoe, J., Owen, R., Macnaghten, P., 2013. Developing a framework for responsible innovation. *Res. Policy* 42, 1568–1580. <https://doi.org/10.1016/j.respol.2013.05.008>.
- Stirling, A., 2010. *Keep it complex*. *Nature* 468.
- Stirling, A., 2008. Opening up” and “closing down”: power, participation, and pluralism in the social appraisal of technology. *Sci. Technol. Hum. Values* 33, 262–294. <https://doi.org/10.1177/0162243907311265>.
- Taebi, B., Kwakkel, J.H., Kermisch, C., 2020. Governing climate risks in the face of normative uncertainties. *Wiley Interdiscip. Rev. Clim. Change* 11, 1–11. <https://doi.org/10.1002/wcc.666>.
- te Kulve, H., Rip, A., 2011. Constructing productive engagement: pre-engagement tools for emerging technologies. *Sci. Eng. Ethics* 17, 699–714. <https://doi.org/10.1007/s11948-011-9304-0>.
- Termeer, C.J.A.M., Dewulf, A., 2019. A small wins framework to overcome the evaluation paradox of governing wicked problems. *Policy Soc.* 38, 298–314. <https://doi.org/10.1080/104494035.2018.1497933>.
- Termeer, C.J.A.M., Dewulf, A., Biesbroek, R., 2019. A critical assessment of the wicked problem concept: relevance and usefulness for policy science and practice. *Policy Soc.* 38, 167–179. <https://doi.org/10.1080/104494035.2019.1617971>.
- Transitieteam Bouw, 2018. *Transitie-agenda circulaire bouweconomie*.
- Truffer, B., Voß, J., Konrad, K., 2008. Mapping expectations for system transformations lessons from sustainability foresight in German utility sectors. *Technol. Forecast. Soc. Change* 75, 1360–1372. <https://doi.org/10.1016/j.techfore.2008.04.001>.
- Turnheim, B., Sovacool, B.K., 2020. Exploring the role of failure in socio-technical transitions research. *Environ. Innov. Soc. Trans.* 37, 267–289. <https://doi.org/10.1016/j.eist.2020.09.005>.
- Turnhout, E., Metzke, T., Wyborn, C., Klenk, N., Louder, E., 2020. The politics of co-production: participation, power, and transformation. *Curr. Opin. Environ. Sustain.* 42, 15–21. <https://doi.org/10.1016/j.cosust.2019.11.009>.
- Unruh, G.C., 2000. *Understanding carbon lock-in*. *Energy Policy* 28, 817–813.
- Uyarra, E., 2024. *Creating national governance structures for the implementation of EU missions mutual learning exercise on EU missions implementation at national level*. Brussels. <https://doi.org/10.2777/724815>.
- Uyarra, E., Flanagan, K., Wanzelböck, I., 2023. *The Spatial and Scalar Implications of missions: Challenges and Opportunities for Policy*. Manchester Institute of Innovation Research working paper series.
- Van de Poel, I., de Wildt, T., van Kooten Passaro, D., 2022. Values for a no-growth future. In: Dennis, M.J., Ishmaev, G., Umbrello, S., van den Hoven, J. (Eds.), *Values for a Post-Pandemic Future*. Springer Nature Switzerland AG, pp. 23–58. <https://doi.org/10.1111/j.1540-6385.1976.tb00713.x>.

- Van de Poel, I., Fahlquist, J.N., Doorn, N., Zwart, S., Royakkers, L., 2012. The problem of many hands: climate change as an example. *Sci. Eng. Ethics* 18, 49–67. <https://doi.org/10.1007/s11948-011-9276-0>.
- Van de Poel, I., Zwart, S.D., 2010. Reflective equilibrium in R&D networks. *Sci. Technol. Hum. Values* 35, 174–199. <https://doi.org/10.1177/0162243909340272>.
- van der Burg, S., 2009. Taking the “soft impacts” of technology into account: broadening the discourse in research practice. *Soc. Epistemol.* 23, 301–316. <https://doi.org/10.1080/02691720903364191>.
- van Mierlo, B., Beers, P.J., 2020. Understanding and governing learning in sustainability transitions: a review. *Environ. Innov. Soc. Trans.* 34, 255–269. <https://doi.org/10.1016/j.eist.2018.08.002>.
- Vaughan, N.E., Lenton, T.M., 2011. A review of climate geoengineering proposals. *Clim. Change* 109, 745–790. <https://doi.org/10.1007/s10584-011-0027-7>.
- von Hippel, E., 2005. *Democratizing Innovation*. MIT Press.
- Von Schomberg, R., 2013. *A Vision of Responsible Research and Innovation, Responsible Innovation: Managing the Responsible Emergence of Science and Innovation in Society*. John Wiley & Sons, Chichester, UK. <https://doi.org/10.1002/9781118551424.ch3>.
- Voß, J.P., Bornemann, B., 2011. The politics of reflexive governance: challenges for designing adaptive management and transition management. *Ecol. Soc.* 16. <https://doi.org/10.5751/ES-04051-160209>.
- Voß, J., Truffer, B., Konrad, K., 2006. Sustainability foresight: reflexive governance in the transformation of utility systems. In: Voß, J., Bauknecht, D., Kemp, R. (Eds.), *Reflexive Governance for Sustainable Development*. Edward Elgar, pp. 162–188.
- Wang, X., Lo, K., 2021. Just transition: a conceptual review. *Energy Res. Soc. Sci.* 82, 102291. <https://doi.org/10.1016/j.erss.2021.102291>.
- Wanzenböck, I., Frenken, K., 2020. The subsidiarity principle in innovation policy for societal challenges. *Glob. Trans.* 2, 51–59. <https://doi.org/10.1016/j.glt.2020.02.002>.
- Wanzenböck, I., Wesseling, J.H., Frenken, K., Hekkert, M.P., Weber, K.M., 2020. A framework for mission-oriented innovation policy: alternative pathways through the problem–solution space. *Sci. Public Policy* 47, 474–489. <https://doi.org/10.1093/scipol/scaa027>.
- Weber, K.M., Rohracher, H., 2012. Legitimizing research, technology and innovation policies for transformative change: combining insights from innovation systems and multi-level perspective in a comprehensive “failures” framework. *Res. Policy* 41, 1037–1047. <https://doi.org/10.1016/j.respol.2011.10.015>.
- Wesseling, J.H., Meijerhof, N., 2023. Towards a mission-oriented innovation systems (MIS) approach, application for Dutch sustainable maritime shipping. *PLOS Sustain. Transform.* <https://doi.org/10.1371/journal.pstr.0000075>.
- Wiarda, M., Coenen, T.B.J., Doorn, N., 2023a. Operationalizing contested problem-solution spaces : the case of Dutch circular construction. *Environ. Innov. Soc. Trans.* 48, 100752. <https://doi.org/10.1016/j.eist.2023.100752>.
- Wiarda, M., Doorn, N., 2023. Responsible innovation and societal challenges: the multi-scalar dilemma. *J. Respon. Technol.* 16. <https://doi.org/10.1016/j.jrt.2023.100072>.
- Wiarda, M., Sobota, V.C.M., Janssen, M.J., Kaa, G.Van De, Yaghmaei, E., Doorn, N., 2023b. Public participation in mission-oriented innovation projects. *Technol. Forecast. Soc. Chang.* 191, 122538. <https://doi.org/10.1016/j.techfore.2023.122538>.
- Wittmann, F., Hufnagl, M., Lindner, R., Roth, F., Edler, J., 2021. Governing varieties of mission-oriented innovation policies: a new typology. *Sci. Public Policy* 48, 727–738. <https://doi.org/10.1093/scipol/scab044>.
- Xiang, W.N., 2013. Working with wicked problems in socio-ecological systems: awareness, acceptance, and adaptation. *Landsc. Urban Plan.* 110, 1–4. <https://doi.org/10.1016/j.landurbplan.2012.11.006>.
- Yalew, S.G., Kwakkel, J., Doorn, N., 2021. Distributive justice and sustainability goals in transboundary rivers: case of the Nile Basin. *Front. Environ. Sci.* 8. <https://doi.org/10.3389/fenvs.2020.590954>.
- Young, I.M., 2002. *Inclusion and Democracy*. Oxford University Press.
- Zehner, O., 2012. *Green illusions: the Dirty Secrets of Clean Energy and the Future of Environmentalism*. University of Nebraska Press.