Responsible innovation as empowering ways of knowing

Govert Valkenburg, Annapurna Mamidipudi, Poonam Pandey & Wiebe E. Bijker

Published online: 13 Aug 2019.

Submit your article to this journal ↗

View Crossmark data ↗

Routledge
Taylor & Francis Group

RESEARCH ARTICLE

Responsible innovation as empowering ways of knowing

Govert Valkenburg [a,b], Annapurna Mamidipudi [a,c], Poonam Pandey [a,d] and Wiebe E. Bijker [a,b]

[a]Faculty of Arts and Social Sciences, Maastricht University Science, Technology and Society Programme, Maastricht University, Maastricht, Netherlands; [b]NTNU Norwegian University of Science and Technology, Trondheim, Norway; [c]Max Planck Institut für Wissenschaftsgeschichte, Berlin, Germany; [d]Department of Science and Technology, Centre for Policy Research, Indian Institute of Science, Bangalore, India

ABSTRACT

In pursuit of *responsible research and innovation* (RRI), emphasis has been on various forms of inclusion in the governance of science, technology and innovation. Given that much of the ideas on inclusion in fact refer to *discursive* inclusion, it is surprising that little attention has hitherto been paid to what seems foundational to any discursive space: ontologies (theories of being) and epistemologies (theories of knowing), and notably how these relate to inclusion and exclusion. By means of an action-research case study on responsible innovation on biogasification in rural India, we show that one important mechanism of exclusion exists in a dispossession of epistemological agency and the rendering of ontologies as anomalous, even if this is not directly visible as social exclusion. We argue that RRI should adopt as one of its central values the *epistemological* empowerment of relevant groups.

Introduction

Responsible Research and Innovation (RRI) has emerged as a vast science policy literature that addresses amongst others the question of how to make governance of science, technology and innovation (STI) more inclusive in terms of the publics they serve and represent, and more responsive to the dynamics and uncertainties that innovation inherently entails (Macnaghten et al. 2014; Owen, Macnaghten, and Stilgoe 2012; Von Schomberg 2013). Although this implicitly builds on the inclusion of knowledges other than formal expertise, little attention has been paid in the literature to the challenge of reconciling knowledges, when they are so far apart that they fail to recognize each other as valid knowledge. This paper discusses how people can be empowered to contribute from their own knowledge position, to processes of governance.

We take a constructivist, grounded approach to knowledge: rather than specifying a theoretical account upfront, we call knowledge whatever actors refer to as knowledge. We are thus open to a broad range of entities that may count as knowledge: the 'stuff'

that scientists consolidate in journal papers, but also what craftspeople teach their apprentices in embodied, narrative and metaphorical ways. This way, knowledge is inseparably connected to the first-person perspective that an actor holds to the world: their *knowledge position.* We take such a knowledge position to be rooted in an *epistemology* or conception of what it takes for knowledge to be true or valid. This epistemology may remain implicit in actors' own accounts of knowledge.[1] Only through recognition of such knowledge positions does it make sense to critically discuss the exclusion of knowledges.

The inclusion of knowledges is central to RRI, although we take the critical stance that this inclusion is usually insufficiently substantiated in its conception of knowledge. Two notions that circulate within RRI discourses, 'inclusion' and 'responsiveness' (Stilgoe, Owen, and Macnaghten 2013), do in fact promote such knowledge inclusion. Inclusiveness does this seemingly straightforwardly. Responsiveness does so in a more instrumental sense (Reed et al. 2009; Stirling 2007): with a broader knowledge base, governance is more likely to be able to respond to the emerging challenges (Jasanoff 2002, 379). Yet, seminal publications (e.g. Von Schomberg 2011) do not elaborate the notion of inclusive deliberation (see also Di Giulio et al. 2016). RRI can thus be understood as the next step in the traditions of *technology assessment* (TA) and *constructive technology assessment* (CTA). These sought input to STI beyond mere technological expertise, and proactively charted the societal context in which STI would operate (Klüver, Nielsen, and Jørgensen 2016; Rip, Misa, and Schot 1995). Yet, critique has been levelled against seeing RRI as the continuation of TA, for example, because it disregards the diversity in TA approaches (Delvenne 2017).

It is vital to distinguish *social* inclusion from *epistemic* inclusion. Social inclusion amounts to ensuring that people have access to governance processes such that they can contribute to discussions on an issue. This is hard enough: considerable economic, social and political barriers may stand in the way for people to participate in these processes. Still, warranting that people have access to sites of decision making is not the same as granting that their knowledge will be received or exert any influence. Social inclusion easily disregards the diversity in knowledge positions. Additionally, the problem is reflexive: the boundary between social inclusion and epistemic inclusion is itself constructed and connected to particular ontological and epistemological positions.

Regarding *epistemic* inclusion, the question is: how can a heterogeneous assembly[2] of actors be made to contribute meaningfully to processes of innovation and governance, especially if they are divided by incompatible epistemologies? Granting people the ability and authority to speak cannot be seen apart from the ability to speak from their particular knowledge position. In exploring this problem, we coin the notion of *epistemological trust* for the ideal when parties recognize knowledges from alien epistemologies that may seem nonsensical from their own epistemology.

It needs recognition that 'inclusion' is an essentially asymmetric notion. It presumes a core site where knowledge is produced and decisions are made, and a periphery. Those from the periphery can at best be 'emancipated' – an equally asymmetric and problematic term – such that they can contribute to the governance process, or only be acknowledged as voiceless, and at worst remain utterly invisible. This resonates with Haraway's (1988) notion of *unmarked categories*: members of dominant classes are privileged to define the classes and how these matter, as well as to position themselves as exempt from classification. They in effect position themselves as universal and neutral; as 'unmarked'.

We assume that epistemological divides stand in the way of empowering relevant groups and entrusting them with the governance of STI. This points at a new value to be realized in RRI, and governance of STI in general: the democratization of the *validation* of knowledge (Visvanathan 2009). The knowledge positions that we assumed to be rooted in an epistemology even if this is not a typical Western-scientific epistemology, need to be enabled to demonstrate how their knowledge is true and valuable. If such democratization is not in place, we should be pessimistic about the possibility of knowledge to deliver any benefits to governance and innovation in substantive, instrumental or normative ways (Stirling 2007). This is not meant to disqualify scientific knowledge in favour of 'alternative facts'. But it does say that if science's criteria for knowledge are applied to all knowledge proper, important knowledges are lost only because they are of a different form (see also Fuller 2012; Guston 2013).

As a strategic research site to explore these issues, we investigate an innovation project in biogas production from rice straw in rural India. The innovation problem has many sides. First, there is the technology that is as yet insufficiently mature to function in the field. Second, there is the problem that currently most of the rice straw is burnt, causing massive problems of air and soil pollution. The problem ramifies wide and multiple problem definitions circulate. Also, the relevant actors are heterogeneous. Therefore, it cannot be taken for granted that all relevant knowledge can unproblematically be integrated in the innovation process. We find that, both socially and epistemologically, stakeholders are not available by default (Pandey, Valkenburg, Mamidipudi, and Bijker, forthcoming).

From this case study, we propose an additional sensitivity to epistemic empowerment that RRI needs to incorporate. Governance of STI needs to cope with the challenges emerging from epistemological divides between actor groups. From our case study, it follows that articulating issues that people can relate to and own as their responsibility, is on its own insufficient. It also takes effort to bring incompatible epistemologies to the same table. Translation is needed between them, and due attention must be paid to each. Neither prioritizing between them nor exclusion of some is wise. And neither should truthfulness be attributed uncritically to any of them.

Deliberation in a situation of epistemological divides

The naiveté of inclusive deliberation

One thread running through traditions of RRI, TA and CTA is the recognition that other knowledges than formal expertise pertain to innovation processes, and that a broader range of stakeholders is therefore to be consulted. Reasons for such consultation include practical considerations to build a better overall knowledge base, to have a better decision-making process, or to make decisions more democratically sound from some normative, political-philosophical consideration (Bidwell 2009; Jauho 2016; Renn, Klinke, and van Asselt 2011; Stirling 2007). In practice, such inclusion helps to broaden the range of perspectives on a problem. If actors can bring their perspective to bear on the issue, they are also more likely to recognize both the problem and its eventual solution to be theirs. Also, as more knowledge from the context of operation – as a somewhat artificial distinction from the context of research and development – is included, it is likely that the implementation will be better adapted to that context.

Whether or not stakeholders are in practice able to influence decisions may depend on various factors, including systemic and spatial exclusion, racial and gender exclusion, access to information, and socio-economic means (Teelucksingh and Poland 2011). Also, parties may be excluded deliberately from such arenas (de Saille 2015). This social inclusion has been addressed widely (see Fung 2003 for an overview).

In view of this diversity of causes for stakeholders to be absent as well as a diversity of reasons why they should be present, it is remarkable that most approaches to stakeholder inclusion are comparably uniform in their focus on deliberative methods (Stilgoe, Owen, and Macnaghten 2013). According to Owen, Macnaghten, and Stilgoe (2012), RRI is about 'making the right impacts', which are to be determined through deliberative democracy. Also, RRI's imperative of being 'responsive' to the needs of society (Owen, Macnaghten, and Stilgoe 2012) is highly predicated upon collecting those needs along deliberative lines.

Some criticism has indeed been levelled against the 'deliberative default' of stakeholder inclusion. This approach, when applied uncritically, undermines the value of inclusive deliberation at multiple levels. First, it generally reduces inclusive deliberation to a bureaucratic tokenism prescribed in standardized formats that are mechanistically performed in order to move forward (Owen et al. 2013). Second, it obfuscates the ongoing power struggles and efforts (especially in the Global South, including India) to legitimize inclusive deliberation as a tool to democratize governance of STI (Grunwald 2019; Ladikas and Hahn 2019; Pandey and Hahn 2018). Third, it under-appreciates the normative as well as practical capacities of exercises like TA to make a political impact (Grunwald 2019; Hennen and Nierling 2019; Van Est 2019).

As Stilgoe, Owen, and Macnaghten (2013) review, moves towards deliberative democratization can themselves be subject to framing effects that reinforce existing power relations, not least by constructing particular kinds of publics. Similarly, Van Oudheusden (2014) argues that instead of naively assuming that deliberation will lead to better democracy, it should be articulated how the rules of engagement themselves are negotiated, and how inclusion and exclusion are achieved. The latter are now largely hidden under a seemingly non-political vocabulary deployed in RRI literature (Van Oudheusden 2014, 81). Sand (2019) shows how the practice of inclusion (specific formats of visioning and imagining and language of expression) might severely limit the enriching potential of deliberative exercises and may end up re-enforcing elite visions of S&T governance.

Research has provided reasons why deliberative processes fail. As Gregory (2016) argues, deliberative inclusion easily escalates, ultimately compelling decision makers to bypass the deliberation results. Mistaking quantity for quality, initiatives sometimes only produce long lists of undifferentiated concerns, little clarification and consultation of expertise, and no sign of engaging in controversial issues. Similarly, Guston (2013) shows how anticipatory deliberative processes are too much akin to the modus operandi of the technosciences, and adopt technoscience's tendency to approach the future as something to take control of. In general vein, Chilvers and Kearnes (2015) argue that existing approaches often assume that the 'public' to be involved is somehow pre-existing and available for enrolment.

Yet, as Stilgoe, Owen, and Macnaghten (2013) argue, there have also been proposals to repair these deficits. It has been shown that many initiatives to deliberation do at least produce desirable outcomes, even if not perfect. Also, Guston (2013) shows that despite these epistemological hazards, it still proves beneficial to amplify voices that would

otherwise remain unheard. If technoscientists are made to discuss the matter outside their own workplaces and outside their own modes of thinking, they are compelled to think more explicitly about the normative sides to their work. This is presumably beneficial, even if no clear account is given of how these voices do represent specific ontological and epistemological positions.

In a constructivist understanding of public engagement, the relevant public for a particular discussion is not preordained, but emerges in, or is constructed as a consequence of, specific democratic processes (Michael 2009). It has indeed been articulated that deliberation processes themselves construct and enact specific publics (Chilvers and Kearnes 2015, 33; Mitzschke 2018; Stilgoe, Owen, and Macnaghten 2013, 5). Not only does any social-scientific method to some extent create the social world it studies (Law 2009), but also methods of public engagement might literally become 'eventful' and produce unforeseen interactions among the public that go beyond merely harvesting their opinions (Lezaun and Soneryd 2007). It cannot be assumed that the public is 'out there', waiting to be included in deliberative processes (Mitzschke 2018).

This construction of publics is inevitably (also) epistemological. Deliberation is fundamentally dependent on the possibility of discourses to emerge, and shared ways of knowing to be mobilized. If participants to a democratic forum mobilize narratives that are too far apart, fruitful discourses will likely not emerge. One example is the language of Punjabi farmers with its spiritual metaphors regarding the land. This stands in contrast with the scientific language of innovators in New Delhi. This prima facie observation makes one wonder whether and how a meaningful conversation between them could emerge. Our educated guess would be that the innovation experts will draw the longest straw concerning their ability to determine the terms of debate (Wynne 2001, 2003), and that the farmers will face barriers to get the content of their knowledge recognized (Pandey, Valkenburg, and Bijker submitted).

To the present case, a naïve implementation of deliberative participation would consist of simply bringing farmers and corporate players to the same table, and let them discuss the issue, as if this were enough to bring on board the perspectives of farmers. However, this would disregard the specificity of rules of engagement between farmers and corporates, and the fact that the negotiation of these rules is contingent upon existing power relations. The latter would put to question the possibility of the exchange of knowledge to take place. This closely relates to the fundamental observation by Fuller (2012), that certain knowledges not only acquire dominance, but also become the criterion by which other knowledges are assessed.

Epistemologies are closely connected to ontologies, or 'theories of being': the way persons know their world, rooted in an epistemology, is closely connected to how they conceive of that world. For example, different ontologies might order differently what counts as practical knowledge and what counts as belief systems or ethics. Thus, if all actors are to be treated fairly, the ontologies that order their world view need to be taken into consideration. Being accounts of reality and the conditions of reality, ontologies are tied up with how people intervene in reality, which makes the mobilization of ontologies political: *ontological politics* (Mol 1999, 2002). Acknowledging one ontology and not another is a political act in its limitation of interventions (politics of ontology). In addition, by performing particular ontologies, actors stake their territory and render holders of other ontologies powerless (politics by ontology). Consequently, multiple ontologies

exist at the same time, which, with Mol, we take to be more fundamental than a simple coexistence of multiple perspectives or interpretations. As Barad (2007, 185) argues, ontologies, epistemologies, and their politics are inextricable, which is why she talks of ethico-onto-epistemologies. Also, prioritizing ontologies and epistemologies has consequences, including that knowledge exchange potentially becomes problematic. This will be central to our case study.

The empowerment of publics requires that onto-epistemic differences are dealt with. Including new stakeholders into deliberation should ultimately be about empowering their epistemologies. Not only should people be enabled to speak, they should also be able to do so in a way that presents their knowledge position as legitimate, and the epistemology in which their position is rooted as valid. This is what we call *epistemological agency*. One element of the construction of publics, that has hitherto received fairly little attention, is the mending of exactly these epistemological boundaries and epistemological agencies (see also Visvanathan 2009). Not only might there be no shared vocabulary between parties, also the parties' accounts of the world might be so divergent as to prevent any shared recognition of problems and potential solutions. Moreover, dominant onto-epistemologies may include a subordination of other epistemologies, thus silencing the latter (see Cech et al. 2017 for a similar example).

Thus, a relevant actor is not only one who is *de facto* able to make a meaningful contribution. This would disregard people who are excluded because of incompatible epistemologies, or because ontologies are enacted that render them such. The realm of relevant actors should also include those who can *potentially* make a meaningful contribution, i.e. those who are able to propose an ontology.[3] This points at a key element of stakeholdership: not only should people be formally entitled to make a contribution, they should also be empowered to propose an ontology and to supply it with a validating epistemology.

Towards epistemological empowerment

Essentially, the problem we observe in the case study is that ontologies are enacted, in tandem with their accompanying epistemologies, which hampers the free flow of knowledge. Given the heterogeneous and ramified nature of the innovation problem, we assume that some degree of free flow of knowledge would be beneficial to arriving at a contextually robust solution. In the remainder of this section, we present some thoughts about how to achieve a freer flow of knowledge.

The first step is to recognize a paradox. On the one hand, we need to acknowledge that multiple onto-epistemological positions exist. Also, we must assume that they are rational, meaning that they are internally consistent and open to some form of critique, and that they are therefore legitimate. On the other hand, accepting each and every fact stated by a legitimate epistemology as true would not bring us very far. Some of the facts stated by different parties are in contradiction, and even when facts are shared, they may be ranked differently in importance among other facts. Also, there is no denying that plain ignorance and even stupidity exist – only, as social scientists, we should avoid this explanation and only use it as a very last recourse. (Also, caution is due as apparent stupidity and ignorance might simply result from our own ontological and epistemological postitions, see Michael 2011). Thus, epistemic inclusion needs a strategy to strike a balance between granting truth to positions and critiquing those positions. Our challenge is not primarily to assess

each epistemology on its own quality, but rather to deal with the fact that not all epistemologies and ontologies are equally positioned to critique other positions, as they may lack the agency to engage in the ontological and epistemological politics needed.

The second step is to work on either horn of the paradox. Recognizing the different positions and their legitimacy requires that we articulate the boundaries between them and respect these boundaries, to create a safe space for each actor to present their ontology. Simultaneously, these differences, and the unequal distribution of epistemological agency need attention. Here, subordinate positions require special care: without specific support, they might not be able to present their knowledge in the broader arena.

The two sides of the strategy coincide with how Bijker, Bal, and Hendriks (2009) have articulated the construction of expert authority, which is at the same time tied to principles of democracy and inclusion, and to principles of expert knowledge making and seclusion. They show that expertise needs at the same time public spaces where it is held accountable ('front stage'), and spaces where it can operate freely and bounded only by its own internal criteria ('back stage'). Thus, in fact, in these two types of space, different criteria for validity apply. In similar vein, the connection between different epistemologies and ontologies needs on the one hand modes of operation where mutual comparison and prioritizing of elements takes place, and on the other hand spaces where they can be reflected upon without questioning them.

In the following, we will interrogate the case of rice straw fermenting in rural India, and identify barriers to stakeholder involvement that are produced through the enactment of ontologies and epistemologies. These barriers may concern the enrolment, availability and accessibility of stakeholders. They may also concern stakeholders' effective participation once they arrive at the discussion table. We aim to move beyond social and institutional barriers to participation, and focus specifically on the epistemic and epistemological aspects of inclusion.

The case of rice straw fermenting in rural India

Case introduction

Currently, many farmers in India are working in the so-called *rice-wheat system*. This uses farmland alternatingly to grow wheat and rice within a year cycle. After harvesting, the farmland needs to be vacated of the straw before the next crop can be sown. Many farmers currently burn the straw. This engenders various problems, including smog and soil deterioration. One potential solution is envisioned: instead of burning, the straw could be used in a biogasification process. This would at once solve the smog and soil deterioration problems, and produce gas as a utilizable energy carrier.

At face value, the innovation problem consists of improving the gasification technology. Current technologies are not yet sufficiently capable of dealing with rice straw; it has too much wood-like content, compared to other feedstocks. However, further complexities are easily identified. For such a technology to become viable, more challenges would have to be faced: adaptation of farmers' processes to make the straw available, securing supply, to reach an appropriate scale, warrants for long-term operation to attract investments, etc.

Ramifications of the problem thus abound, which connects it to a broad range of framings and problem definitions. Social inclusion and exclusion are immediately visible in the

differential difficulties for groups to acquire access. We demonstrate how these different positions enact ontologies and epistemologies, and thereby enable and disable knowledge to travel between the holders of those positions. Such barriers may be in place even if access in a social or even physical sense seems to have been provided. In section 4, we will report on the interventions we made.

Case selection and method

The case came to our attention originally as an innovation project, run by a large chemical corporation, and arguably serving the needs of farmers. Given the positions of both the corporation and farmers, it was by no means straightforward that collaboration between them would unfold as fair and unproblematic. Thus, we as RRI researchers were enrolled to provide a proper frame of thinking. We were to add social value, to the value of technical and commercial expertise held by the corporation.

Our empirical data collection consisted of interviews and site visits, supplemented with document research. We also conducted interventional research: by organizing events, we explored possibilities to breed onto-epistemic trust between different knowledge positions, as a way of being symmetric to vulnerable stakeholders' points of view.

The interviews were semi-structured, based on topic lists that contained a number of themes: what people see as the main problem, what its possible solutions are, what stands in the way for those solutions to materialize, and how they believe other groups understand the problem. This allowed interviewees to explain their position in their own terms. Also, reflection was solicited on the larger context, and the barriers interviewees perceived to the possibilities of exchanging knowledge. Access to the interviewees was acquired through snowballing, starting from contacts held by project members. As it was vital to acquire a perspective as broad as possible, we did not exclude any potential interviewee upfront. We deliberately sought to include at least policy makers, academic scientists, corporate scientists, farmers (organic as well as ones working in the rice-wheat system), and societal organizations working with farmers.

The researched documents included academic papers, both social science and chemistry of biogasification; news media coverage of both the straw-burning problem and innovations related to it; and policy documents relating to agriculture and innovation. Most of the material was available online or brought to us, for example by interviewees. We started at these topics that were self-evidently relevant to our research, and the search was not guided by specific concepts or strategies.

By means of intervention, we brought together actors and stakeholders that had not been together in a deliberative setting. We co-organized one Farmers' Day where about 100 farmers from various agricultural paradigms convened and exchanged knowledge regarding local solutions to the burning of rice straw. And we held three workshops where corporates, farmer representatives, innovators, academics and policy makers convened to discuss potential collaborations. We participated in one key state policy meeting on converting rice straw waste to biofuel. While we pursued a modest stance with respect to imposing our conclusions, we did share our own knowledge and insights to offer a contrasting view and invite further reflection. As these events were heterogeneous – each in a different way – they typically produced a dynamic that was of great

interest from an RRI perspective. To all events, we invited key people from relevant social groups, but all events were also publicly advertised and generally accessible (except the meeting with corporate researchers, which was in-company).

From the interviews, site visits and interventions, data was collected using audio and video recordings (if possible). Extensive notes were made of interviews, visits and events, in most cases by multiple researchers. Thus, the interpretation of the interviews was corroborated through intersubjectivity. Within our material, we looked for principal themes we had selected upfront. These included different framings of straw and the chances and challenges it offers; ideas of knowledge, its assessment and its hierarchies; the ways people understand and evaluate technologies (exemplars as well as generic ideas of 'technology'); and how people conceived of social groups, social relations, and distribution of power. The notion of trust, as developed further on in this text, emerged inductively out of the analysis, and was not something we probed on the basis of our own *a priori* conceptions.

Smoke, straw, soil degradation, and squandering

The problem of biogasification first appeared simple, even though there was nothing trivial about the technology. Yet, it seemed simple in the sense that the relevant actors and purposes appeared clearly. A big corporation was working on a technology for which they needed to enrol farmers to make it viable, and where it seemed desirable to put this collaboration under a regime of responsible research and innovation.

The technology itself is far from simple. In fact, some problematic parts of the gasification process have remained insurmountable at the time of writing. Upon our first explorations, the problem proliferated into a network of many problems, including issues of farmers' livelihoods, problems of gender inequality, and problems of soil and air pollution. We first discuss this broader network of problems, temporarily privileging our own perspective and suspending the actors' perspectives. We then gradually move into the different perspectives and problem definitions the actors hold, which we will rearticulate in the next subsection in more conceptual terms of onto-epistemological positions.

India has had a long history with biogas. One narrative trope firmly rooted in Indian collective memory is that of the history of biogas as going back to 1897. A biogas digester was created then that used human waste as a feedstock. In 1939, a digester was successfully constructed that produced biogas from manure (Abbasi, Tauseef, and Abbasi 2012). When discussing biogas, whether with individual interviewees or in workshop-like discussion settings, this history often surfaces. Given that huge amounts of rice straw and wheat straw are – arguably – currently left unutilized, the thought of making it into biogas and thus adding green energy to the national energy balance is never far away either. However, the technology to use rice straw as a feedstock is not mature enough for large-scale rollout.

A first source of complexity appears when we inquire where people reckon the straw comes from. The dominant agricultural paradigm in the areas in point is the aforementioned rice-wheat system, which was an important driver of the Indian Green Revolution.[4] Between two crops, farmers need to empty their fields of residues to vacate them for the next cycle. Setting the residues to fire is often considered the only viable solution. For these farmers, biogasification would not solve their actual problem of emptying the field.

Instead, it would force unto them the chore of collecting the straw and availing it for gasification. Also, they have no need for electricity or gas as both are already provided at little or no cost.

Here, the problem connects to another generally acknowledged problem: the thick plumes of smoke that cover large swaths of North India, including the capital Delhi, twice a year. The burning is mostly concentrated in the states of Punjab and Haryana, but it also happens elsewhere in the country. The smoke is highly toxic, and it causes serious health issues among people. Burning of straw has been prohibited by law, but enforcement is problematic, and found unjust by farmers who claim to have no choice.

The burning is also detrimental to the soil, as it exterminates beneficent microorganisms living in the soil. In addition, some organic farmers argue that the straw contains important nutrients that should rather be redeemed to the soil to serve the next crop cycle. In this light, biogasification is a non-solution: even if it produces utilizable gas, it takes away nutrients. This also complicates the claim to renewable energy benefits: processing straw into gas would not be without cost, as it is simply not a 'valueless non-commodity', despite it being burnt at large scale. Organic farmers see biogas as a competitor to a healthy agricultural ecosystem.

These aspects are mobilized in different constellations by different actors. While we introduced the problem as 'the challenge to make biogas from rice straw', this is not necessarily the form in which it appears as relevant for each of the actor groups. Our interviewees are connected through many different smaller and bigger problems. Not only do they give different accounts of what the problem is and how it matters, they also disagree on possible solutions, and on who is responsible for constructing those solutions.

Staking ways of knowing

During our investigation, we encountered multiple ways of knowing the problem. To some extent, these are simply different perspectives. Insofar as they stem from factual disagreements, further research – whether driven by formal expertise or by other practices of 'truth finding' – could probably bridge the divides. However, some positions appear more fundamentally apart than can be bridged by an act of (mutually recognized) truth finding. In this section, we zoom in on two of those positions. The perspective of organic farmers is fundamentally different from the perspective of those we call the 'core network'[5] of innovators: corporate and academic scientists and policy makers. This notion of core network suggests an opposition to 'periphery', and indeed we aim to show that these core-network actors have an implicit bent towards marginalizing the farmers who they in fact need to enrol. In terms of the framework developed above, they manage to position themselves as the unmarked category, and their epistemology as the gold standard by which the others are evaluated.

Despite the heterogeneity of this core network, there are some storylines that consistently recur from the various actors. As these storylines are mobilized in roughly the same strategic direction, the core network functions as a *discourse coalition* (Hajer 1995; 2005, 302). One narrative trope recurring from the core network is the equation of straw with waste. This suggests that it has no intrinsic cost, and that making it available only requires establishing a supply chain. This storyline of 'straw as waste' is pervasive (see for example Kauldhar and Yadav 2018; Kumar 2018).

At first glance, this understanding of straw as waste seems concurrent with the perspective of farmers working in the rice-wheat paradigm. As mentioned above, the straw is primarily something that these farmers need to get rid of. Even when recognizing the soil degradation that results from the burning, for many farmers it does not outweigh the benefits of timely sowing the next cycle. This is amplified by the fact that multiple state policies incentivize the rice-wheat system. However, at closer look, the story line also downplays the effort that farmers would have to make to collect the straw. It instrumentalizes farmers: they only appear as suppliers of straw, not as owners of knowledge.

When biogasification becomes an option, burning straw consequently becomes a waste of material. Throughout India, it destroys a tremendous amount of biomass. In view of the impending need to green the energy balance, capturing the energy available in biomass and feeding it into the energy system would offer a great step forward. While this view ascribes a certain monetary value to straw, thus de facto elevating it from the waste category, it does also straightforwardly entail that farmers should collect the straw for biogasification.

This core network deeply depends on promises of technological innovation. In the glory days of the green revolution, new technologies did indeed prove capable of pushing the limits of what a passive 'nature' affords to produce. A certain dependence on Green Revolution programmes, together with trust generated through these programmes and policies, has brought exactly that: a comparably stable income and a secure procurement through state-run food security programmes. Trust between farmers, scientists, and the State was bred through the efforts of the State, and state-run extension programmes introduced green revolution technologies through their scientists in Krishi Vigyan Kendras (Farmer Science Centres).

One final thing that the storylines in this discourse coalition share is a preference for higher levels of abstraction and organization: the tremendous amount of biomass that is available at the national level as if that were simply available, the conceptual narrative of a 'supply chain' that sounds much more clear-cut than its implementation in the field would be, a generic trust in 'technological innovation', etc. Thus, to this discourse coalition, local decentralized solutions will appear as anomalous, and irrelevant to solving the bigger problems of clean energy and energy security. Consequently, systemic players such as big corporates and policy actors will be more relevant than individual farmers. And most importantly, it entails a prioritization of formal expertise and a subordination of the knowledge held by farmers – if not a complete rejection.

The second discourse coalition we discuss centres on organic farming. Contrary to the core network of innovators, members of this coalition see straw as a resource of essential nutrients, to be given back to the land for the next crop cycle. This can take the form of either a mulch sheet, or of ploughing the straw back into the soil. The maxim of organic farming is that you reap only from the land what you really need, i.e. the edible parts of a crop. Everything else should be given back, so as to stimulate recovery in the soil. Organic farming maintains an overall philosophy that is strongly aimed at a long-term, circular ecological balance (Pandey et al. submitted).

The organic farmers see soil as the capital that is to be preserved for the future. They emphasize the need to return nutrients to the soil, and the need to give the soil time to recover. Burning the straw is to squander nutritional value and to kill the organisms that make a healthy soil. As organic farmers already put the straw to use, it is not

waste, and it is not available for biogasification. Rather, biogasification would mean: competing for the resource that provides nutrients. This vision thus conflicts with the one held by the core network. Interestingly, the core network promises that biogasification provides manure as well. While sensible from a core-network point of view, this latter position does not fit in the organic-farming ontology, centred on an arguably natural ecosystem. Given the social and epistemological relations as explained in this paper, this renders the organic farmers irrational or ignorant.

Organic farmers have a whole repertoire of ways to make sense of the value and condition of the soil. For example, they manually check which organisms such as worms and insects are present in the soil. They check what the soil looks and smells like, and what its texture and solidity are like. If they can roll a pellet from the soil, this signifies a healthy degree of moisture.

Organic farming maintains different ideals than does farming in the rice-wheat system. With organic farming, the ideal is a situation of ecological balance on the farmland, which is believed to provide the greatest possible resilience. This future is thus independent from technological promises and the uncertainty that comes with them, as is the case with the promises made by the core network. This entails that trust is not put on high-level formal expertise, but on community and tradition: much of the knowledge needed to attain this ecological future, organic farmers argue, is already available in traditional practical knowledge.

Moreover, some organic farmers express the fear that once biogas becomes commercially attractive, it will lead to further instrumentalization of the land. It will stimulate further extraction of bio-value from the land. Thus, in their paradigm, there is no place for commercial biogas plants: while they give back something, they do not give back as much as the organic way of farming does.

The organic farmers have a clear account of how they 'know' the land. They do not use the word 'epistemology' when explaining how they know things, but when asked, they usually have an explanation of how their knowledge is valid. Also, they often present their way of knowing in explicit opposition to the ways of knowing held by the core network. Members of the core network, according to the organic farmers, only know nature in ways that instrumentalize it and rob it of its good.

Thus, the organic farmers denounce the core network of innovators in a specific, epistemic way: they see the core network as advocates of irrelevant and even evil knowledge. At the same time, organic farmers themselves experience that the core network of innovators are deaf and blind towards the knowledge they, organic farmers, hold dear. They typically reason along the lines that their organic-farming knowledge is unattractive to the core network because it would not entail a business model for corporates. Hence it becomes unattractive to see the truth in it. Above all, the organic farmers see their ways of being and their ways of knowing the land as permanently under pressure from the greater powers behind the Green Revolution and the rice-wheat system, namely the core network. (This is the view our informants attributed to the core network, not necessarily actually held by the core network. Also, it is not universally accepted, see, e.g. Jamwal 2018.)

Epistemological divides

We thus identified two principal ontologies and accompanying epistemologies. It is tempting to think of these as different versions of the same problem, that only place emphasis on

different parts of the problem and balance competing interests differently. However, the fundamental ramifications of these positions provide compelling reasons to think of them as in fact representing different realities, with different problems and different potential solutions. The problems have different owners and different parties responsible for their solution. They have different causes and different effects. Thus they are pockets of knowledge that are in important senses incompatible.

In addition, it becomes clear that the core network indeed positions itself as the unmarked category. However, this does not appear as an explicit move of stating that the organic farmers are ignorant or irrational. Instead, it happens through the presentation of the innovation space as a specific distribution of epistemological agency and task division: the main problem is defined as technical and thus stays with the core network, and the periphery is rendered responsible only for putting in place a supply chain. Compared to the technical innovation, the challenge of the supply chain appears as merely organizational and not scientific or technological, even if it may in practice not be all that easy.

The subordinate position of organic farmers speaks from the fact that even though they have an explicit account of the knowledge position of the core network, they see no possibility to challenge it. To echo Visvanathan (2009), they have no possibility of *critiquing* the knowledge position of the core network. Also, the fact that they have such an explicit account is already different from how the core network is positioned, as the latter seems to have no substantive account of the knowledge position of the former. This is again concurrent with the core network's unmarked position. The organic farmers there only appear as suppliers of straw, not as holders of knowledge.

RRI as breeding onto-epistemological trust

Our intervention aims

In addition to analysis, we have actively engaged with the respective practices. In the course of the 1.5 years of the project, our primary concern converged to the creation of *onto-epistemological trust*: seeking arrangements where knowledges can be presented as true and rational, even among members of incompatible ontologies and epistemologies. This includes that people should be enabled to present reflections on how they know things, and explain how their knowledge is valuable. In this section, we discuss and critically appraise our attempts at this.

Our interventions

We pursued circulation of knowledge at the Farmers' Day, the two two-day workshops (one between State, NGO actors and social scientists and the other between social scientists and engineering scientists), one workshop between corporate actors and social scientists, and participation in a policy meeting with multiple actors working on bio-ethanol production. We sought to bring parties together that represented different ways of knowing the problems listed above. We approached them as groups with particular onto-epistemological positions, even though they are in fact not internally homogeneous. We explored what was needed for knowledge to circulate and for integrated solutions to come about, and how we could promote this.

The Farmers' Day consisted of a relatively homogeneous group. This is not to say that all farmers think alike, and there were even differences of understanding that could be reckoned ontological: e.g. seeing straw as waste versus seeing straw as a resource. Nonetheless, there was enough common ground for a fruitful exchange of knowledge to take place, without one type of knowledge (or one agricultural paradigm that the knowledge was connected to) gaining dominance. In contrast, the other workshops we held were more heterogeneous and came with more controversy.

To illustrate the very idea of knowledge circulation in heterogeneous contexts, in some of the events, we used examples from practices that are not clearly connected to the context of biogasification. Drawing on other cases of innovation from earlier research, we exemplified how knowledge travels, how it works differently in different contexts, how it is differently evaluated. For example, one of us presented on the basis of earlier research how handloom weavers connect to other parties, and how the knowledge they exchange, moves between categories during the exchange: from 'traditional' to 'chemical' to 'embodied' to 'practice-based', etc. (Mamidipudi 2016). Another example was the smart metre controversy in the Netherlands, where privacy concerns of consumer citizens proved to be anomalous to knowledge systems deployed by the designers in charge (Valkenburg 2017). We explicitly staged those examples in a vocabulary of different ways of knowing that each have their validity and usefulness.

In the workshop with corporate actors, our presentations inspired participants to reflect on how issues of social responsibility remain prone to becoming an externality to the core business of profit making. Similarly, in the meeting between engineering and social scientists, research students struggled with the dominance of academic and corporate innovation paradigms over local knowledge systems, which the media pejoratively referred to as 'cow science'. Comparing handloom and biogas as socio-technical practices allowed young engineering researchers to explore vocabularies that looked at cultural aspects of organic farming knowledge that are generally considered as an externality to modern innovation frameworks. In most cases, we saw that further reflection upon people's own ontologies and epistemologies became possible.

Our attempts at breeding onto-epistemological trust should be seen as experiments in *epistemological inclusion*, as a specific part of inclusive deliberation. By first recognizing boundaries of expertise between groups, validating such expertise by other epistemic groups in the various settings, and collectively examining externalities generated in each of those domains of knowledge, reflexivity as well as circulation of knowledge across boundaries was achieved.

Intervention results

In our public meeting, clearly a front stage, farmers responded to accusations by citizens and policy makers from the city of Chandigarh of flouting of environmental laws. They explicated how farmers do not make the problem alone, but so do the state and citizens who are not willing to pay for the added costs of environmentally safe food production. Standing up to the authority of environmental laws, they rejected the criminalization of farmers, and instead asserted their role as the producers of the food that the country needs so badly. In effect, farmers here appeared as experts. Media members in the audience applauded their stand, and even asked why they had been silent for so long. This is thus a

shift in the broader perception of rice straw burning as a criminal activity attributed to farmers, towards a common recognition of economic and environmental vulnerabilities associated with the various farming paradigms. This shows that once it is recognized that authority is a relational thing, and the right effort is made (and allowed to be made) to establish this relation, it can change.

Similarly, lack of epistemic authority undercuts organic farmers' confidence in talking about their own innovations and expertise. At multiple other instances, in heterogeneous settings like these, organic farmers often demand the scientific experts to study and validate their knowledge claims to make them more commonly acceptable. The disconnect between their knowledge systems and knowledge systems external to their practices also causes them to mistrust technologies that are promoted by the state and large corporations. Yet, in the farmers meeting, encouraged to speak of innovations at individual farm level that ameliorated burning of rice straw, farmers demonstrated evident technical expertise. Their knowledge was validated in the meeting itself and accepted. As the meeting progressed, peers evaluated interventions, and responded by clamouring for the mobile telephone number of the one who proposed a particularly effective solution. In the absence of authoritative expertise that could overrule their local expertise, the emerging onto-epistemic trust validated their own technical knowledge, and allowed organic farmers to become more nuanced about the utility of technology in general as well as the relative worth of their knowledge.

We observed that the multiplicity of problems was a loyal ally in our aim to keep the discussion open, and in preventing the discussion from becoming dominated by particular knowledge positions. Even though participants at times really stuck to their positions, we managed to keep the dialogue open, and no actor acquired onto-epistemological dominance to silence others. We used this productively by initiating discussions that made visible the externalities of all frames and problem definitions, creating opportunities for reflexivity with respect to actors' own frames.

A recognition of the need to connect different epistemic worlds was reflected when, during the policy meeting, a key policy maker cautioned against keeping agriculture and energy contexts separate. Rather, considering their interwoven economies, both realms had to be considered – whether at the local or at the national level, and would require the state departments of energy and agriculture to talk to each other on joint policy making. This requires mechanisms that build onto-epistemic trust through collaborative problem-solving. Rather than dismissing farmer concerns as irrelevant to energy security, epistemic authority needs to be rearranged such that their solutions are recognized as knowledge.

Concluding remarks

RRI seeks to broaden the input to governance of innovations. We showed how this broadening needs to include the challenging of epistemological dominance. Shaping RRI in a context where epistemological and ontological divides seem insurmountable requires further effort to ensure stakeholder inclusion at the epistemological level. It is vital to create safe spaces where different positions can meet, without any of them acquiring a dominant position and imposing its particular knowledge criteria onto others. This we consider true diversity: a structure that equally empowers diverse epistemologies. This is a value for democracy in general, and for the governance of STI in particular.

Our case study shows how deliberation as the main approach to democratizing research and innovation ultimately requires an effort to bring stakeholders into existence as actors and as *epistemic and epistemological agents*. Being a responsible researcher may include taking up the challenge of explicating the epistemic and ontological claims of those who are otherwise only constructed as stakeholders in the dominant scientific, policy and market frames. While it has been argued that deliberation is by no means a panacea (Chilvers and Kearnes 2015; Van Oudheusden 2014), we show that such hurdles are not only about different levels of expertise and socio-political inclusion, but also about inclusion of ontologies and epistemologies.

From our limited explorations, it remains speculative to what extent people in our biogasification case have *fundamentally* revised their positions, and what epistemological divides have been bridged. We need to reckon with the possibility that people just acted 'in a socially desirable way', rather than critically revisiting their own epistemologies. However, even if this is the case, it still seems that a proper facilitation contributes to a participative democracy that is more conducive to symmetric epistemic relations amongst diverse actors.

The onto-epistemological divides we articulated add to existing divides of underlying socio-economic and class conflicts. This is one point at which the distinctly Indian perspective of our case study adds weight: as seems common in India, it unfolds at the crossroads of modern, Western-style innovations, and traditional practices and knowledges. This brings together fundamentally different ideals of democracy and inclusion as well as innovation and knowledge. Not only is the latter understudied in RRI and adjacent fields, it is also that such western studies are not by default receptive for Indian philosophies, which may for example reject a strict separation between facts and norms (Sarukkai 2009).

We contend that, apart from these Indian specificities, socio-economic and class differences *per se* are insufficient to explain the boundaries we encountered. Onto-epistemological differences are indispensable in explaining why there might in fact never emerge a single problem definition. In addition, in line with ideas on *intersectionality* (Cooper 2016), it should be assumed that such different systems of inclusion and exclusion reinforce and interlock one another. Thus, enabling people to challenge hierarchies of knowledges might also destabilize such interlocked inequalities, and hence contribute to empowerment and equity in a more generic social sense. Building onto-epistemological trust might connect groups that would otherwise remain divided by class differences and other social barriers.

Finally, in contrast to the framing of straw as waste and as an externality to the system of Green-Revolution farming, organic farmers do have a long-term perspective on where innovation should go. They pursue prosperity through their relational view to ecology, with cyclicity and equilibrium as central principles. That their caring for 'Mother Earth' does not fit well with core-network's frames should not be seen as disproving their knowledge, but rather as a point of critique to be directed at innovation leaders: instead of discrediting it, innovation needs to open up its own ontological and epistemological presumptions and allow for alternative ones to speak up.

Notes

1. At this point we find ourselves limited by our own Western position, and we disregard the possibility that people do not evaluate their own knowledge in terms of truth and a justifying

epistemology, see, e.g. Leach and Davis (2012). We deem this unproblematic for the current argument, and resolving it would be beyond the current scope.

2. We speak of *assembly* here, as alternative notions such as 'group' or 'community' suggest some form of internal coherence, which is exactly what is missing here, at least at the onto-epistemological level.

3. Even though made at a very different level of analysis, this point takes inspiration from Jansen (2017), who proposes a similar correction to *actor-network theory*.

4. We use Green Revolution in the distinctly Indian meaning of the term, referring to the technology-driven agricultural boom that the country witnessed in the second half of the Twentieth Century. Our use of the term is unrelated to other uses, such as e.g. the one deployed by Mazzucato, Semieniuk, and Watson (2015).

5. This notion obviously takes inspiration from the notion of 'core set' (Collins 1981), which was meant to refer to those scientific experts that are able to contribute to a certain controversy, because of their knowledge as well as their institutional situation. The ramifications of this concept are not considered relevant for the current argument.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

Notes on contributors

Govert Valkenburg is a researcher at NTNU Norwegian University of Science and Technology, Trondheim, Norway. His research has focused on normative, political and governance issues in science, technology and innovation, with a particular focus on citizenship, knowledge, and epistemic justice. Fields of interest have included energy and sustainability, privacy and security, and medicine and (human) biosciences.

Annapurna Mamidipudi earned her PhD at Maastricht University on the thesis 'Towards a theory of innovation in handloom weaving'. She was trained as an engineer before she established and worked for over 15 years in an NGO that supported vulnerable craft livelihoods. Her research interests include the study of traditional craft in the contemporary world, particularly handloom weaving as embodied knowledge and the politics of sustainable development.

Poonam Pandey holds a PhD from the Centre for Studies in Science Policy, Jawaharlal Nehru University. After working at Maastricht University, she is now affiliated to the Centre for Policy Research, Indian Institute of Science, Bangalore, India. Her research interests have included sociotechnical imaginaries, nanotechnology, and responsible research and innovation.

Wiebe E. Bijker is professor at NTNU Norwegian University of Science and Technology, Trondheim, Norway, and professor emeritus at the Maastricht University Science, Technology and Society (MUSTS) research programme, Maastricht University, the Netherlands. His research has focused on the relation between technology, society and science. Since the 1990s political and normative issues have been central in Bijker's research. He is founding co-editor of the monograph series 'Inside Technology' of MIT Press.

ORCID

Govert Valkenburg http://orcid.org/0000-0001-7045-9878
Annapurna Mamidipudi http://orcid.org/0000-0002-0145-0631
Poonam Pandey http://orcid.org/0000-0002-2296-6821
Wiebe E. Bijker http://orcid.org/0000-0002-7307-8330

References

Abbasi, T., S. M. Tauseef, and S. A. Abbasi. 2012. "A Brief History of Anaerobic Digestion and 'Biogas.'" In *Biogas Energy*, 11–23. New York: Springer.

Barad, K. 2007. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham: Duke University Press.

Bidwell, D. 2009. "Is Community-based Participatory Research Postnormal Science?" *Science, Technology, & Human Values* 34 (6): 741–761.

Bijker, W. E., R. Bal, and R. Hendriks. 2009. *The Paradox of Scientific Authority: The Role of Scientific Advice in Democracies*. Cambridge, MA: MIT Press.

Cech, E. A., A. Metz, J. L. Smith, and K. de Vries. 2017. "Epistemological Dominance and Social Inequality." *Science, Technology, & Human Values* 42 (5): 743–774.

Chilvers, J., and M. Kearnes, eds. 2015. *Remaking Participation*. London: Routledge.

Collins, H. M. 1981. "The Place of the 'Core-set' in Modern Science: Social Contingency with Methodological Propriety in Science." *History of Science* 19: 6–19.

Cooper, B. 2016. "Intersectionality." In *The Oxford Handbook of Feminist Theory*, edited by L. Disch and M. Hawkesworth, 385–406. Oxford: Oxford University Press.

Delvenne, P. 2017. "Responsible Research and Innovation as a Travesty of Technology Assessment?" *Journal of Responsible Innovation* 4 (2): 278–288.

de Saille, S. 2015. "Dis-inviting the Unruly Public for SaC Forum: 'Publics as Threats to Technoscientific Progress.'" *Science as Culture* 24 (1): 99–107.

Di Giulio, G., C. Groves, M. Monteiro, and R. Taddei. 2016. "Communicating through Vulnerability: Knowledge Politics, Inclusion and Responsiveness in Responsible Research and Innovation." *Journal of Responsible Innovation* 3 (2): 92–109.

Fuller, S. 2012. "Social Epistemology: A Quarter-century Itinerary." *Social Epistemology* 26 (3–4): 267–283.

Fung, A. 2003. "Survey Article: Recipes for Public Spheres: Eight Institutional Design Choices and Their Consequences." *Journal of Political Philosophy* 11 (3): 338–367.

Gregory, R. S. 2017. "The Troubling Logic of Inclusivity in Environmental Consultations." *Science, Technology & Human Values* 42 (1): 144–165.

Grunwald, A. 2019. "The Inherently Democratic Nature of Technology Assessment." *Science and Public Policy*.

Guston, D. 2013. "Understanding 'Anticipatory Governance.'" *Social Studies of Science* 44 (2): 218–242.

Hajer, M. A. 1995. *The Politics of Environmental Discourse: Ecological Modernization and the Policy Process*. Oxford: Oxford University Press.

Hajer, M. A. 2005. "Coalitions, Practices, and Meaning in Environmental Politics: From Acid Rain to BSE." In *Discourse Theory in European Politics. Identity, Policy and Governance*, edited by D. Howarth and J. Torfing, 297–315, London: Palgrave Macmillan.

Haraway, D. 1988. "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective." *Feminist Studies* 14 (3): 575–599.

Hennen, L., and L. Nierling. 2019. "The Politics of Technology Assessment." *Technological Forecasting and Social Change* 139: 17–22.

Jamwal, N. 2018. "Small Farms Can Be Profitable." *Down to Earth*, September 19. (www.downtoearth.org.in). https://www.downtoearth.org.in/coverage/small-farms-can-be-profitable-11182.

Jansen, T. 2017. "Beyond ANT: Towards an 'Infra-language of Reflexivity.'" *European Journal of Social Theory* 20 (2): 199–215.

Jasanoff, S. 2002. "Citizens At Risk: Cultures of Modernity in the US and EU." *Science as Culture* 11 (3): 363–380.

Jauho, M. 2016. "The Social Construction of Competence: Conceptions of Science and Expertise among Proponents of the Low-carbohydrate High-fat Diet in Finland." *Public Understanding of Science* 25 (3): 332–345.

Kauldhar, B. S., and S. K. Yadav. 2018. "Turning Waste to Wealth: A Direct Process for Recovery of Nano-Silica and Lignin from Paddy Straw Agro-waste." *Journal of Cleaner Production* 194: 158–166.

Klüver, L., R. Ø. Nielsen, and M. L. Jørgensen, eds. 2016. *Policy-oriented Technology Assessment Across Europe. Expanding Capacties*. Houndmills, Basingstoke, Hampshire: Palgrave Macmillan.

Kumar, V. R. 2018. "Turning Crop Residue into Useful Products." *The Hindu Business Line*, November 15. https://www.thehindubusinessline.com/companies/turning-crop-residue-into-useful-products/article25505782.ece

Ladikas, M., and J. Hahn. 2019. *The Case for a Global Technology Assessment: Constructing a Global Technology Assessment: Insights from Australia, China, Europe, Germany, India and Russia*. Karlsruhe: KIT Scientific.

Law, J. 2009. "Seeing Like a Survey." *Cultural Sociology* 3 (2): 239–256.

Leach, J., and R. Davis. 2012. "Recognising and Translating Knowledge: Navigating the Political, Epistemological, Legal and Ontological." *Anthropological Forum* 22 (3): 209–223.

Lezaun, J., and L. Soneryd. 2007. "Consulting Citizens: Technologies of Elicitation and the Mobility of Publics." *Public Understanding of Science* 16 (3): 279–297.

Macnaghten, P., R. Owen, J. Stilgoe, B. Wynne, A. Azevedo, A. de Campos, J. Chilvers, et al. 2014. "Responsible Innovation across Borders: Tensions, Paradoxes and Possibilities." *Journal of Responsible Innovation* 1 (2): 191–199.

Mamidipudi, A. 2016. *Towards a Theory of Innovation in Handloom Weaving in India*. Maastricht: Maastricht University.

Mazzucato, M., G. Semieniuk, and J. Watson. 2015. *What Will it Take to Get Us a Green Revolution? No More Nudging. Pushing on Supply and Pulling on Demand*. Falmer, Brighton: University of Sussex.

Michael, M. 2009. "Publics Performing Publics: Of PiGs, PiPs and Politics." *Public Understanding of Science* 18 (5): 617–631.

Michael, M. 2011. "What Are We Busy Doing?" *Science, Technology, & Human Values* 37 (5): 528–554.

Mitzschke, A. 2018. *Elusive Publics. Understanding Techno-scientific Controversy and Democratic Governance in the GM Crops Debate*. Maastricht: Maastricht University.

Mol, A. 1999. "Ontological Politics. A Word and Some Questions." *The Sociological Review* 47 (S1): 74–89.

Mol, A. 2002. *The Body Multiple: Ontology in Medical Practice*. Durham, NC: Duke University Press.

Owen, R., P. Macnaghten, and J. Stilgoe. 2012. "Responsible Research and Innovation: From Science in Society to Science for Society, with Society." *Science and Public Policy* 39 (6): 751–760.

Owen, R., J. Stilgoe, P. Macnaghten, M. Gorman, E. Fisher, and D. Guston. 2013. "A Framework for Responsible Innovation." In *Responsible Innvoation. Managing the Responsible Emergence of Science and Innovation in Society*, edited by R. Owen, J. Bessant, and M. Heintz, 27–50. Chichester: John Wiley & Sons.

Pandey, P., and J. Hahn. 2018. "What Makes Research Responsible? An Indian Perspective." *TATuP. Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis* 27 (3): 63–66.

Pandey, P., G. Valkenburg, and W. E. Bijker. submitted. "'All We Want, is to Get Rid of the Straw': How Biofuel Policies Need to be Multiple." *East Asian Science, Technology and Society*.

Pandey, P., G. Valkenburg, A. Mamidipudi, and W. E. Bijker. Forthcoming. "RRI in the Global South: Agriculture, Renewable Energy and the Pursuit of Symmetry." *Science, Technology and Society* 25 (2).

Reed, M. S., A. Graves, N. Dandy, H. Posthumus, K. Hubacek, J. Morris, C. Prell, et al. 2009. "Who's in and Why? A Typology of Stakeholder Analysis Methods for Natural Resource Management." *Journal of Environmental Management* 90 (5): 1933–1949.

Renn, O., A. Klinke, and M. van Asselt. 2011. "Coping with Complexity, Uncertainty and Ambiguity in Risk Governance: A Synthesis." *Ambio* 40 (2): 231–246.

Rip, A., T. J. Misa, and J. Schot. 1995. *Managing Technology in Society-The Approach of Constructive Technology Assessment.* London: Pinter.

Sand, M. 2019. "On 'Not Having a Future.'" *Futures* 107: 98–106.

Sarukkai, S. 2009. "Science and the Ethics of Curiosity." *Current Science* 97 (6): 756–767.

Stilgoe, J., R. Owen, and P. Macnaghten. 2013. "Developing a Framework for Responsible Innovation." *Research Policy* 42 (9): 1568–1580.

Stirling, A. 2007. "'Opening Up' and 'Closing Down': Power, Participation, and Pluralism in the Social Appraisal of Technology." *Science, Technology & Human Values* 33 (2): 262–294.

Teelucksingh, C., and B. Poland. 2011. "Energy Solutions, Neo-liberalism, and Social Diversity in Toronto, Canada." *International Journal of Environmental Research and Public Health* 8 (1): 185–202.

Valkenburg, G. 2017. "Security Technologies versus Citizen Roles?" *Science as Culture* 26 (3): 307–329.

Van Est, R. 2019. "Thinking Parliamentary Technology Assessment Politically: Exploring the Link between Democratic Policy Making and Parliamentary TA." *Technological Forecasting and Social Change* 139: 48–56.

Van Oudheusden, M. 2014. "Where are the Politics in Responsible Innovation? European Governance, Technology Assessments, and Beyond." *Journal of Responsible Innovation* 1 (1): 67–86.

Visvanathan, S. 2009. "The Search for Cognitive Justice." *Seminar* 597.

Von Schomberg, R. 2011. *Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Technologies Fields.* Brussels: Directorate General for Research and Innovation.

Von Schomberg, R. 2013. "A Vision of Responsible Research and Innovation." In *Responsible Innovation*, edited by R. Owen, M. Heintz, and J. Bessant, 51–74. London: John Wiley.

Wynne, B. 2001. "Creating Public Alienation: Expert Cultures of Risk and Ethics on GMOs." *Science as Culture* 10 (4): 445–481.

Wynne, B. 2003. "Seasick on the Third Wave? Subverting the Hegemony of Propositionalism." *Social Studies of Science* 33 (3): 401–417.