Turning Straw to Gold: Mobilising Symmetry in Responsible Research and Innovation

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This article aims to reflect on the role of Science, Technology and Society (STS) research(ers) in co-constructing Responsible Research and Innovation (RRI) in the Global South. By reporting on RRI research in the Global South, here the Indo-Dutch NWO-MVI project on rice straw burning in Punjab, we make an argument for approaching RRI as a symmetric process of knowledge production mobilised by local actors and researchers alike. For STS researchers to responsibly engage with local innovation systems, their activities need to go beyond knowledge provision and towards facilitating the ownership and circulation of local meanings and means to responsibly innovate. Rather than understanding RRI as a fixed framework to govern innovation practices, this article reflects on RRI as an approach that combines research with intervention. We propose that following the principle of symmetry can turn RRI into a productive tool for the mobilisation of embedded local principles that can organise innovation systems in a responsible way. In particular, symmetry allows the re-location of meanings and practices of innovation as well as the re-negotiation of multiple notions of responsible governance.

Introduction

The case for Responsible Research and Innovation (RRI) in the Global South seems straightforward: In order to align innovations with local needs and concerns, an

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inclusive governance framework is required which accommodates multiple actors upstream in the innovation process. After decades of critique of techno-scientific development agendas and persisting hegemonies generated through universalistic governance models, RRI figures as a promising approach to re-embed innovation in its place of emergence. Scholars in Science, Technology and Society (STS) have not only been central in foregrounding such participatory[1] approaches to the governance of science and technology but they also play a key role in researching the conditions of and propose tangible solutions for innovation systems to become more 'responsible'. Yet tasked increasingly by European institutions with the project to mobilise the RRI framework in the Global South, STS researchers are confronted with a major tension: How to navigate on the ground without repeating linear ideas of knowledge transfer from North to South, this time under the guise of *responsible innovation*? How to responsibly facilitate the emergence of local systems of *responsible innovation*?

In this essay, we[2] reflect on the tensions that arise for the STS researcher in mobilising RRI in the Global South. We posit that understanding and practicing RRI as a governance model that can easily be transferred from the desks of STS researchers and halls of European policymakers to local contexts may risk letting the fabled camel into the tent, which the STS scholar must confront. Two major tensions serve as a baseline for our reasoning: One along the North–South divide, the other among policy frameworks and STS theory. Our arguments are illustrated through a two-year research project on the 'Responsible Production of Biogas in India', which was funded by the Dutch research council Nederlandse Organisatie voor Wetenschappelijk Onderzoek through its Platform for Responsible Innovation (NWO-MVI),[3] and where one of us figured as a researcher.[4] Addressing research as one of the many practices of knowledge-making, our lens is turned to ourselves, the researchers—not only as analysts but also as actors among many others in finding responsible ways to innovate the recycling of rice straw in India. We claim that by mobilising a basic tenet of STS—the principle of *symmetry*—in knowledge production, we can facilitate the recognition, circulation and negotiation of plural epistemologies through which responsible innovation systems might emerge in local contexts.

To think and act symmetrically vis-á-vis diverse epistemologies provides fruitful ground for countering the hierarchisation of actors and knowledge-claims in processes of research. Such a reflection is particularly relevant where systems of innovation are characterised by stark cognitive inequality and vulnerabilities that determine livelihoods, as is the case for farmers in the region of Punjab and their struggle to find a solution for the environmental and social damages produced by rice straw burning in India. Through focusing on moments in the project where hierarchies—financial, social, cultural—that effect *epistemic justice* are negotiated, we illustrate how acting and thinking with *symmetry* can facilitate the attribution of innovation and its governance to their place of emergence.

The essay uses vignettes from the research process which act both as data and as moments that provoke us to reflect on the manifold inequalities and strong asymmetries that abound in this context. We show how such moments of reflection

were generative for mobilising *symmetry* in research practice, with which pre-constructed boundaries could be bridged. Before delving into the vignettes, we give a brief contextualisation of our reflections, which centre around the tension of mobilising RRI as a governance framework in the Global South, while keeping intact the core value of *symmetry* that characterises STS research. *Symmetry*, we propose, mediates the challenge of appending *responsible*—or any other prefix—to the word *innovation* that seeks to govern its direction and content, and makes RRI a worthwhile enterprise for responsible STS research.

Tensions in Mobilising RRI in the Global South

Discourses around responsibility in processes of innovation have a long trajectory in approaching the governance of science and technology in modern democratic societies, and are gaining renewed attention in our times (Lengwiler, 2008; Mody, 2016). In the face of the first accounts of the 'Limits to Growth', attention to questions of responsibility, particularly with regard to the effects of technological progress on eco-systems and the environment, triggered new conceptualisations of the relationship between technology and society (Bruntland Commission, 1987; Jonas, 1985; Meadows, Meadows, Randers, & Behrens, 1974). Social studies of science and technology evolving in parallel to such discourses identified how an increasing reliance on science and technology creates *risk societies*, which are characterised by *organised irresponsibility* (Beck, 1986, 1988), that is, lacking means to assign accountability for the consequences of industries and technologies on societies and their environments. The questionable capacity of scientists and engineers to govern themselves in a responsible way, and to be responsive to the societies they aim to serve, has since been subject to STS scholarship, critique and engagement (Bijker, 2010; Brown, 2009; Jasanoff, 2011; Sismondo, 2008).

In light of recent experiences with public resistance to the top-down introduction of emerging technologies into societies, such as genetically modified organisms or nanotechnologies, inclusive and participatory frameworks are gaining new currency in the governance of innovation (Chilvers & Kearnes, 2015; Owen, Macnaghten, & Stilgoe, 2012). Embedded in Anglo-American and European schools of thought, these frameworks are often developed in and for socio-technical systems of the Global North, and can be read as responses to broader critiques of a 'crisis' of science and technology in modern democracies (Brown, 2009; Law & Lin, 2017). Attempts to reform the relationship between participatory and democratic decision-making and cultures of self-governing science and technology are manifesting particularly in Europe through the framework of RRI. During the last decade, RRI has been gradually included in and further institutionalised by the European Union's (EU) Horizon 2020 Framework Programme[5] (De Saille, 2015), where it figures as a cross-cutting theme to better align European R&D with its heterogeneous publics.

Although definitions of RRI are still in flux, prominent attempts at synthesising instruments and concepts under the umbrella of RRI share the language of collective decision-making, early integration of stakeholders, anticipation of future

consequences and a more flexible system of governance. More often than not, it is presented as a set of principles, such as the EU's five elements of RRI (*public engagement, open access, gender, ethics, science education*), or Stilgoe, Owen, and Macnaghten's (2013) four dimensions of responsible innovation (*anticipation, inclusion, reflexivity, responsiveness*).

Whereas STS has consistently argued for a context- and culture-specific governance of science and technology, the policy rhetoric of RRI today reads as a 'one-size fits all' style of governance, with wide repercussions for the operationalisation of responsible innovation instruments and practices. Such a trajectory should not surprise the analyst, given the reliance on universal models of innovation and innovation governance in science, technology and innovation policy (Pfotenhauer & Jasanoff, 2017a). Further, as Eizagirre and colleagues note, '… the inclusionary or political eagerness represented through RRI must grapple with the strategic imperative of competitiveness and economic development' (Eizagirre, Rodríguez, & Ibarra, 2017, p. 20).

The divergence between RRI's constructivist framing in STS and RRI's mobilisation by policymakers and funding and research institutions confronts the STS researcher with a dilemma. Whereas STS has advanced the principle of *symmetry* in order to show how knowledge claims are always inherently contingent, and should not be hierarchised by the analyst in terms of true and false beliefs, it encounters the essentialist character of techno-scientific politics which rely on causal and deterministic explanations of knowledge-making (Gieryn, 1995; Stone, 1997), including what is considered to be the *responsible* production of science and technology. *Symmetry*, in the words of David Bloor, requires '(a)ll beliefs (…) to be explained in the same general way, regardless of how they are evaluated' (Bloor, 1976, p. 158). Such a methodological relativism does not inhibit the STS scholar from taking a normative stance vis-á-vis claims of knowledge and their consequences for society, but binds analysis to be open towards the manifold interpretations of the world around us, as well as ways for acting upon it with technological means (Bijker, 2003). This openness runs the risk of being closed down by the institutionalisation of RRI in terms of prescribed principles, which leave little room for culturally embedded ways of reasoning about and governing the development of science and technology (Jasanoff, 2005).

As the research project on 'Responsible Innovation in Biogas in India' laid bare, the challenge of navigating the politics of RRI on the ground is not only a theoretical one, and cannot be reduced to the intellectual sensitivities of STS alone. The marginal uptake of RRI language and practice beyond the EU indicates how RRI is still very much a European Agenda (Lavrijssen et al., 2017), which is difficult to mainstream within Europe itself, let alone beyond its borders (Davies & Horst, 2015). Federico Vasen, for example, criticises that while '(…) the RRI discourse is relevant to Latin America, (…) the tools and cases proposed do not fit with the main local concerns' (Vasen, 2017, p. 94). Concepts such as *Frugal* and *Grassroots Innovation* that emerge from scholarship in and are addressed towards the Global South largely remain outside the domain of RRI, even though they seem to address

a similar set of concerns (Bhaduri & Kumar, 2011).[6] That such *Epistemologies of the South* (De Sousa Santos, 2012) are not considered more substantially in discourses around RRI gives attempts of mobilising it in the Global South a post-colonial flavour, regardless of its opposite intention (Pandey, 2016).

Models of linear knowledge and technology transfer have enjoyed thorough critique from STS scholars and have often resulted in resourceful but ineffective policies with regard to so-called 'pro-poor' innovations (Thomas, Fressoli, & Becerra, 2012). For instance, the concept of *socio-technical resistance* captures how local communities often counter the hegemonic apparatus of innovation policies, which allows '(…) to generate a socio-material basis adequate to their view of the world or to prevent the stabilization of technological systems adverse to their visions' (Thomas, Becerra, & Garrido, 2017, p. 198). RRI's current operationalisation in policymaking and funding institutions does not favour such a resistance—in fact, it reduces participation to a *Machinery for Making Publics* that stabilise hegemonic narratives of modernist progress (Blok & Lemmens, 2015; Felt & Fochler, 2010; Leach, Scoones, & Wynne, 2005).

Sticking to the principle of *symmetry*, in contrast, requires that researchers carve out and confront these hegemonies. To remain symmetrical when mobilising RRI in the Global South, the STS researcher has to be reflexive in relation to both, governance *and* innovation: towards local cultures of (responsibly) governing processes of innovation as well as towards local understandings of (desirable) innovation itself. Pre-defined RRI principles, which are to be operationalised in local contexts by the STS researcher, also entail an a priori understanding of innovation and its rightful place in society. Where techno-scientific development agendas have worked as subtle forms of social engineering mediated through imperatives of progress (Visvanathan, 1997), RRI risks becoming yet another policy project subordinating local populations to 'right and wrong' modes of governance and visions of socio-technical change. These are the tensions we aim to address in the following pages, showing how the mobilisation of *symmetry* by the STS researcher can take RRI back to its constructivist roots, and turn it into a productive approach towards generating locally desirable as well as responsibly governed innovation.

Mobilising Symmetry: Five Vignettes from the Ground

… Between Social and Technical Domains

> *How can rice straw that is being burnt as waste by farmers in Punjab and causing environmental damage be converted to sustainable biogas that can benefit farmers?*
> —Project proposal to NWO-MVI, Responsible Production of Biogas in India, 2015

The answer to this question is innovation. In a meeting[7] attended by scientists and social science researchers on 'Nanotechnology for Development', a senior scientist[8]

working in an Indian subsidary of a Dutch chemical technology company and heading its social innovation centre in India outlined a problem that his team could provide a solution for. Annually, farmers burn 17 million metric tons of rice straw in the Punjab region of India, causing air pollution that brings the nearby city of New Delhi almost to a standstill. The solution would be a pre-treatment technology that breaks down rice straw into biogas, turning waste into sustainable energy. The additional social ambition of the project was that biogas technology would then enter the circular economy of the farmer, instead of being siphoned away from the local community for commercial use driven by corporate interests. To achieve this, he touted the idea of a partnership between his team and STS scholars.

This was a sentiment that resonated with the Dutch NWO-MVI call for proposals of 2015–2017 which asked 'How do you bring about responsible innovations that enjoy broad societal consensus? How do you make better products and services?'. It posited that R&D that is tackled in a socially responsible manner would not hinder growth and opportunities in the market but can instead accelerate these—here RRI was claimed to be a 'tried and tested formula'.[9] Under this motto, the project for 'Responsible Production of Biogas in India' was taken up in partnership between the Corporate DSM-India and Maastricht University researchers, proposing a symmetric engagement with both the social *and* technical goals of the project.

… Between Science and Spirituality as Claims of Truth

> *We want to go on airplanes, and you want us to go back to gobar gas and bullock carts?*
>
> —Large farm owner, Krishi Vigyan Kendra, Punjab, 2016

On the prospects of biogas as solution to the rice straw burning problem, a large farm owner collaborating with the Krishi Vigyan Kendra (Agricultural Science Centre) in Punjab responded with some heat. His implicit assumption was that progress was achieved through moving forward with modern science and technology—technology thus was the prerogative of scientists, and the newer, the better. Biogas with its inner functioning laid bare in smelly dung pits in backyards. It did not make the cut against piped gas black boxed in red cylinders.

Biogas had been in use in rural India since 1900, through methods of composting that generated methane, as an alternative to coal. It was referred to as *gobar* gas or cowdung gas, a name that has stuck to it, to the present. During the Second World War, as by-product of nitrogen rich fertilisers, it acquired visibility as alternative cooking fuel in the appropriate technology movement of the 1970s (Raina & Chanakya, 2017). Yet the idea of being a poor man's technology came in its way, and the appellation of *gobar* gas acquired a pejorative aspect, as backward technology. While biofuels are currently perceived as the most promising option for clean fuel in Europe, requiring cutting-edge technology to break down lignocellulose-based inputs, to the Indian farmers themselves biogas speaks of a downmarket technology smelling of cow dung and the rural past.

Swinging to the other side, NGO leader Umendra Dutt, a farmer activist from the NGO Kheti Virasat Mission (Farming Heritage Mission), pointed to the negative effects of the displacement that modern technology had engendered. Foregrounding Green Revolution technology's negative aspects in farming in Punjab, he posited it as a destructive monster. Displacement of old ways of farming with new technological regimes in his experience inevitably caused disenfranchisement[10] of vulnerable farmers. In addition, fundamental cultural notions of good and bad were displaced. Talking in terms of value neutrality to technology is problematic for those who take a stand against the negative aspects of technology, he cautioned. Instead, he pleaded for spiritual notions of farming.

How can the researcher who seeks to be symmetrical adopt the framework of (responsible) innovation without a certain technological rationality being embraced? The very notions of what is conservative, or progressive, comes into question when traditional organic farmers, who seem to provide the most durable solution to the rice straw burning problem, do so using spiritual terms—those of *Dharti Maa*, Mother Earth, and their duty, or *dharam,* towards her.[11]

In resolving this dialectic between different claims of truth,[12] thinking symmetrically with RRI was hence better conceived not so much as value neutrality but as tolerance (at least for the duration of the conversation) of other actors' notions of good and bad, whether old (regressive/traditional) or new (progressive/modern), and regardless of where the actor's value system was exactly rooted and acquired. Such tolerance became essential if actors bearing different epistemic values, whether spiritual or modern-scientific, were to work together to solve problems as a responsible innovation system.

Framing care as a common concern for the future, symmetry was used to bridge the discursive distance between science and spirituality as ways of knowing. At the end of the two-year project, a key recommendation focused on the missing cultural perspectives in current debates around the problem of rice straw burning. It stressed the importance of learning from organic farmers who incorporated a culture of care and commitment to their land into their technical and social practices, despite economic vulnerability: *The unsung heroes of the problematics are in fact the organic farmers*.[13] Innovation and sustainability thus were not to be understood as fixed notions, packaged by the researchers and transferred to foreign places but rather as emergent from local contexts, and explicated as such.

… Between Linear Design and Implementation

How is the project different from the old linear model of design implementation, where the innovation is in the technical-design phase, and the job of social scientists is then of mechanistical implementation in society?
—Question from the NWO-MVI project reviewer, 2015

Framing a solution of biogas production to the problem of rice straw burning already in the design phase of the project created a design/implementation asymmetry.

Indeed, it was presumed that by using RRI as a framework, research projects would identify the ethical and societal aspects of technological innovations at an early stage so that these could be considered in the technical design process, reducing costs at a later implementation stage.[14] Given that stakeholders might be identified at a later stage in the project, how could their solutions be brought into play?

In response to this question, the researchers argued against a deterministic and for a constructivist account of responsibility in innovation. First, they recognised *interpretive flexibility*—that different groups attribute different meanings and interpretations to each technological artefact—in defining which problem is at stake in the Punjab case, and that innovative solutions on the ground could change problem definitions. Second, the researchers affirmed the capability to innovate solutions by those living with economic vulnerability. Poor but knowledgeable farmers were not to be conceived as passive consumers of innovation but as pro-active innovators (Mamidipudi & Bijker, 2018). Third, the researchers claimed, problem-solving is a back and forth process, rather than a moment in time and space—responsibly innovating socio-technical systems is always work in progress. The propensity of a system to keep problem definitions open became key to offset the effects of linear temporality between design and implementation.

Farmers' knowledge and innovations that researchers encountered during the course of the project were foregrounded in the final recommendations to the Indian state, breaking out of the linear design implementation logic the reviewer had cautioned against.[15] This was facilitated by the corporate partner DSM India, which brought to bear its not inconsiderable clout with the state, brokering a collaboration for the research team with a senior government official in the Ministry. His interest was to *turn rice straw to gold*—or, in this case, 2G ethanol—in order to comply with international agreements for bringing down greenhouse gas emissions and meet India's goal to bring down oil imports.

Running in parallel to the project period, to this end, an innovative policy move[16] in the area of biofuels was made. This entailed the moving of biofuels work from the Ministry of New and Renewable Energy (MNRE) to the Ministry of Petroleum and Natural Gas (MoPNG), with the intent of scaling biofuel production. This allowed capital rich and government-owned oil marketing companies to invest[17] in developing and adopting new 2G ethanol production technologies, with biogas as a by-product, rather than depend on traditional sources of credit capital that often are risk averse in relation to new technologies (Groves, Sankar, & Thomas, 2018).

Yet decision-makers from the Ministry were keen to incorporate farmers' knowledge into this policy, recognising that regardless of a preference for large-scale technological systems, in this context, small and marginal farmers had to be brought on board. Researchers from the RRI team were able to report on farmers' meetings, through demonstrating the links between the socio-technical systems that worked across energy and food security paradigms. As a result, the revival of state interest in the industrial production of biogas was informed by concerns of shared material and human resources between the two systems. Importantly, policymakers shifted from framing farmers as elements of a supply chain who would

implement top-down policy decisions, to taking their knowledge of long-term care and nurturing of environmental resources into consideration in the design of policy.

… Between Technological Regimes

> *Biogas from rice straw: Which biogas will win?*
> —PI of the project Wiebe Bijker on Constructing Worlds as an STS scholar,
> Valedictory Lecture at University of Maastricht, 2017

For most farmers, rather than being a problem, the burning of rice straw is a solution. Pushed into producing crops back to back in order to 'feed the nation',[18] the farming community had already moved once from organic farming practices to Green Revolution technologies in the latter half of the twentieth century. In managing the waste now being generated, for farmers, the collection of straw for conversion into biogas was an additional burden, and burning it was a solution. For the state, the ambitious national biofuel programme building on 2G ethanol was the solution, with the potential of using biogas as a substitute for natural gas, if rice straw could be efficiently collected, transported and eventually distributed after conversion to biogas.

Using constructivist STS as analytic, not just one but eight possible technological regimes for biogas were encountered in the course of the research. Each biogas was the outcome of the working of a different socio-technical system, made up of different social groups, technologies and institutions—one of them even a 'holy biogas', since cow dung had the best bacteria to break up rice straw. This went back to ideas of local sustainability and recycling where nothing is 'waste', at a time when cows were part of every (Hindu) household, treated as almost part of the family, and loved and prayed to. For the researcher not only to understand but also to act symmetrically upon them, there could be no a priori identification of what the problem and its best solution could be. More important, there also should not be losers: Every solution only seemed to displace vulnerability—to a new geography, a new group, or in time.[19]

In the example of rice straw burning being framed by policymakers as economic, it dislocated the problem onto cost of labour and inputs that could be solved by government subsidy. Here, the technological regime was that of the chemical pesticide and fertiliser intensive Green Revolution model. The social issues and politics of caste were dismissed in this problem definition, as were receding water tables, locking out a trajectory of more sustainable farming. The solution was framed as one of converting the waste rice straw into biofuels. As a result, the unsustainability of overproduction of food in Punjab was locked in, demanding long-term commitments from vulnerable farmers to continue to overproduce rice straw in order to regulate price volatility.[20] This solution tied together systems of national food security and energy security in a way that made both vulnerable (Bijker, Hommels, & Mesman, 2014).

In contrast, organic farmers argued that this problem could be solved only through dissenting with this technological regime as a whole. Their cultural

framework to describe their organic farming expertise posed a challenge for the organic technological regime in recruiting not only other farmers, and the public at large, but also policymakers and scientists who use the language of science and economics. A weakness of their narrative of cultural pride was that their interventions in organic farming were not understood as scientific, and were therefore not seen by others to offer credible solutions to the larger national problem of food and fuel security.

There was not a clear better solution, since each regime carried its own vulnerabilities. If one problem definition was not to win over the other, then the responsible solution to rice straw burning in Punjab needed to address concerns from both technological regimes. Such a symmetrical approach embedded responsibility within the negotiation of solutions between these diverse social groups.

When researchers mobilise RRI not just as frame of analysis but also as site of negotiation of diverse technological regimes, the work of coordinating across multiple interests, vulnerabilities and knowledge cultures is foregrounded. Knowledge must cross social, cultural and epistemic boundaries and barriers for responsibly innovating systems to work. It was when cultural knowledge of farmers was circulated as innovation, when corporates invested in societally relevant research (even when business cases did not yet exist) and when the state took on board issues of long-term sustainability in agriculture when planning for future energy security that the problem of rice straw burning began to be addressed. These, we propose, are outcomes of acting symmetrically with RRI in a context of diverse technological regimes—of treating all problem definitions, and all the possible biogases as equally relevant in defining conditions for responsible governance. Then, *symmetry* becomes an essential condition for the robust travel of knowledge across technological regimes.

… Between Dominant and Marginal Actors

What is your mobile number?
—Question from the audience to farmer at farmers meeting organised as part of the RRI project, Bahawalpur village, Punjab, 2016[21]

In a meeting of NGOs, famers' unions and organic farmers organised by the research team in the village of Bahawalpur, around hundred farmers met to discuss the problem of rice straw and to learn more about those who had found solutions other than burning. Initially skeptical about organic farmers' solutions' capability to scale, by the end of the day, the farmers were engaged in discussing the nuts and bolts of techniques that formed alternatives—mulching, composting, diversifying to name a few. Actors who had been marginalised as 'backwards'[22]—the organic, small- and medium-holder farmers who had taken to non-pesticide, non-fertiliser farming in the last decade—now moved at the centre of attention.

Rather than producing rice straw in excess and dealing with it as waste, organic farmers diversified crops, and excess biomass was recycled back into the land as

nutrient or as fodder for the livestock. In their perspective, land was to be valued, nurtured, nourished and replenished. They held themselves responsible for long-term and sustainable use of natural resource—their solution to the problem would be to generate less waste biomass. Following that lead, project researchers focused on organic farmers as possible innovators for the problem of rice straw burning. They were able to evidence knowledge circulation between the farmers; the final validation of that expertise explicated as the moment when members of the audience asked for a farmer's mobile number in order to know more. Farmers clearly were able to recognise innovations that other farmers had made to solve problems that they were facing. Researchers, through organising the meeting among farmers and being symmetrical about its participants' definition of problems and solutions, facilitated a space where the attribution of innovation came from farmers' peers, who had a fine awareness of practical knowledge in farming. This helped in the circulation of knowledge needed to unpick the complex conglomeration of problems—of resource, time, labour, propensities—that resulted in rice straw burning as a solution on the ground.

Proposing organic farming as a solution required that scholars keep interpretative flexibility open to the different meanings of innovation of the varied players. Not closing out vulnerable groups' meaning-making processes proved a challenge for the researchers. If the dominant narrative of solving the problem of waste through powerful corporate-driven innovation for the production of 2G ethanol were stabilised, it would turn farmers into suppliers in a potentially exploitative value chain. On the other hand, in keeping farmers' interpretation of innovation open, there was a danger that the narrative they constructed lost relevance for powerful actors such as the state, the corporate and the Dutch members of the valorisation committee.[23]

A strategic shift was made then by the researchers, back to the principle of *symmetry*: the propensity of innovations for doing good things and bad things in equal measure. By bringing in a common interest in long-term sustainability (the good)—and evidencing that the large-scale production of rice straw may not be sustainable both economically and environmentally (the bad)—an argument was made for innovation that could align the interests of farmers with other powerful social groups. This narrative shift enabled interoperability between the groups, to work with each other despite their different meanings of desirable innovation. The term *innovation* effectively became infrastructure for circulating knowledge between the various specialist groups, and the narrative of innovation that the researchers crafted built interoperability—of technologies, institutional scales and ontologies—that coordinated the working of the complex system.

The meeting was planned in conjunction with farmer groups, and was held in an organic farm, where local farmers provided hospitality to all the visitors and participants of the meeting. Their professions of religious sentiments that respected 'Mother Earth' were demonstrated in the plentiful bounty of the farm for all to see, and the farmers' role of providing food to guests as a spiritual act was validated and deliberately incorporated into the workshop proceedings. These were part of a common cultural framework of responsibility and ethical principles that bound all

Punjabi farmers, not just those practicing organic farming. It helped in moving the frame of innovation outside of modern techno-scientific vocabularies and closer to farmer vocabularies to describe their problems and solutions. Farmers were able to assert expertise, and others to reciprocate by validating it as such, turning the meeting into a hybrid learning environment. In such a space, the use of old and new technologies in knowledge circulation could become seamless both conceptually and in practice—whether sharing techniques of organic farming face-to-face, or through the use of mobile phones.

From being incommensurable as ways of knowing, such common practices form a basis for dialogue. RRI in this mode does not become a tool to merely govern innovations emerging from science and technology, but instead becomes generative of multiple sites of innovation across diverse forms of knowing. In doing so, research practice can create *symmetry* between the study and the governance of innovation.

Conclusion

In a children's fable, having helped the farmer's daughter spin straw into gold, resulting in her marrying the king, the evil imp Rumpelstiltskin demands in return her first-born child. There is a caution here, about the costs of turning straw to gold, particularly on the limits of fixed governance frameworks in dealing with stories of societal change. Principles such as *responsibility* should not be treated as decision procedures that spit out prescriptions, we propose them as organising principles that must aid both individual autonomy and co-ordination of collectives that is necessary for socio-technical change.

Where RRI approaches become a matter of recognising epistemology that determines life chances (Visvanathan, 2005), *participation* alone cannot serve as a principle for governing plural problem-solution definitions and their vulnerabilities. As Shiv Visvanathan has claimed, participation (or public engagement in policy language) is always oriented towards and guided by existing definitions of expert knowledge, in which the layperson's knowledge can only figure as a '… pot-pourri of practices, local ideas and raw material. There is no principle of equivalence' (p. 92). Instead of *participation*, we have shown, the farmers of Punjab embraced *epistemic justice*[24] in a symmetric act that recognised the organic farmer's solution as innovative.

Symmetry can hence strengthen perspectives that are productive for those wrestling with dominant actors' perspectives. This is in line with the shift in discussions from ethics to justice, where the problem shifts from one of powerful scientists exploiting vulnerable subjects to one of powerful institutions exploiting people. Science is no longer the problem (Reardon, 2013); it is the powerful institutional nexus between the corporate and technoscience that is exploitative. Southern NGOs that are battling the nexus through empowering publics already recognise this[25]: they found the framework of RRI that aligns knowledge governance within an idealised institution of social democracy only partially effective in their political battle, which

is to hold the State responsible for the governance of powerful institutional interests that work against poor farmers. Instead, by attributing innovative knowledge to farmers and strengthening their claim of innovation, actors in Punjab achieved recognition for farmer knowledge within policymaking. Symmetric engagement between the different knowledge practices of unequal actors was a necessary and a desirable political outcome—adding to the ideal of economic and social justice the condition of *epistemic justice*.

Mobilising *symmetry* in RRI research demands an enhanced reflexivity towards approaches for aligning innovation and society as tools to generate locally desirable outcomes. Models of innovation governance travel with imaginaries of what innovation and its purpose is, and which knowledge is needed in order to implement it (Pfotenhauer & Jasanoff, 2017b). Recognising that the social contexts of specialised knowledge production both enables and constrains the life world of actors is to recognise the limits of specialised expert knowledge, as being bounded by its specialist focus (Fisher et al., 2015). Acting symmetrically in this context means facilitating the circulation of plural epistemologies and investing in collective meaning-making processes. This, we want to argue, is responsible STS research and intervention.

The organising principle for collective meaning-making processes to be set free is an interplay between the researcher's and the actor's knowledge: Out of that interplay emerged an instance of *epistemic justice* in Punjab, which re-ordered power relationships against hegemonic ideals of progress and development. Then, there emerges a politics of identification—a politics of communal commitment and recognition—through which something foreign is made one's own. Theory does not go 'native', but serves as resource to solve a problem in a new context of use. In Punjab, it was local meanings of commitment and care which turned into a productive narrative for social groups in their quest to find a solution to rice straw burning, as evidenced in the idea of *virasat*, or inheritance, which does not push the problem and therefore its solution into the future. *Virasat* in this case, the inheritance embodied in the land and the knowledge of the community, has to be lived and enacted in the present if it is to be passed on. The local ownership of narratives allows for a collective ownership of problems and pathways to their solution.

If responsible innovations work well and stabilise in society, they embed collective principles that recruit different groups into arrangements that allow problem-solving, even problems that may come up in the future. Rather than techno-scientific imaginaries through which scientific truths travel in time, such arrangements become *socio-technical*, by recognising how—to paraphrase Sheila Jasanoff[26]—through the imaginative work of varied social actors, diverse narratives of collective good become enmeshed in performing and producing science and technology. Changing states of knowledge and societal values (Bellamy, 2016) in the socio-technical system can then be organised through a unifying narrative, rather than a universal truth. Such arrangements can make place for as well as deal with uncertainty, since anticipation of a different desired future does not preclude responsiveness in the present.

The moral of the story? Constructing collective narratives that include problem definitions and solutions of vulnerable stakeholders is important work. In the language of STS, it means to keep interpretative flexibility open—in the real world we engage with and in the scholarly work we produce. When mobilising RRI as an invitation for researchers to think and act on local problems, we need to ensure that our heuristics, tools and principles do not exclude the manifold epistemologies—both powerful and vulnerable—that must work together to make *innovation responsible*. As proposed in this essay, *symmetry* is a constructivist principle worth guiding our thoughts and actions.

DECLARATION OF CONFLICTING INTERESTS

FUNDING

NOTES

1. We are aware that participation is also extensively discussed in development studies (e.g., Cornwall, 2006) and design approaches (e.g., Chesbrough, 2003; von Hippel, 2005), but limit our analysis to perspectives on participation in STS scholarship.
2. Annapurna Mamidipudi was a researcher in this project, Nina Frahm is working on the limits and opportunities of RRI as a governance framework for transnational policymaking. The article is an outcome of conversations in the city of Berlin over the course of 2018, in which a shared concern around the mobilisation of RRI by STS research emerged.
3. See https://www.nwo-mvi.nl/project/responsible-production-biogas-india
4. Researchers in the project were Wiebe Bijker, Poonam Pandey, Annapurna Mamidipudi and Govert Valkenburg, with the support of research intern Amelie Riedesel for the fieldwork in Punjab, to whom we owe intellectual debts.
5. See https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation
6. We thank the reviewers for alerting us to the tendency of 'quick fixes' that most participatory policy frameworks share, whether labelled 'responsible, frugal, grassroots, or inclusive'. Our argument here is not to equate such frameworks, as they have evolved in very different areas of scholarship and address diverging levels and notions of participation and inclusion. Rather, we take the absence of Frugal and Grassroots Innovation frameworks as indicating a general lack of attention towards local knowledge and practices of innovation in RRI policy discourse.
7. Nano-Dev Workshop in Pune 28–29 March 2014.
8. Dr Murali Sastry, Nano-Dev Workshop in Pune 28–29 March 2014.
9. See https://www.nwo.nl/en/research-and-results/programmes/responsible<hig>+</hig>innovation/background
10. Fieldnotes of session 'Technology as Solution' Project Conference in Chandigarh, Punjab, 28–30 November 2016.

11. Fieldnotes Mamidipudi, Jaitu, Punjab April 2016.

12. In general, ideas of participation focus on scientific literacy (Giordano, 2018), given the difficulty in assessing other kinds of knowledge quality (Gregory, 2017).

13. Policy brief on missing cultural perspectives, Delhi/Maastricht, 1 December 2017. See http://www.maastrichtsts.nl/new-policy-brief-about-responsible-innovation-in-biogas-in-india/

14. See https://www.nwo.nl/en/research-and-results/programmes/responsible<hig>+</hig>innovation

15. Policy brief on missing cultural perspectives, Delhi/Maastricht, 1 December 2017. See http://www.maastrichtsts.nl/new-policy-brief-about-responsible-innovation-in-biogas-in-india/

16. See https://www.financialexpress.com/india-news/biofuels-related-work-taken-away-from-ministry-of-new-and-renewable-energy-given-to-oil-ministry/799078/

17. See https://www.downtoearth.org.in/news/energy/on-bio-fuels-in-india-61169

18. Farmers are known as *annadaata*, those who provide food, and those 'who feed the nation' (see http://csa-india.org).

19. Fieldnotes of session 'Technology as Solution' Project Conference in Chandigarh, Punjab, 28–30 November 2016.

20. For a discussion of bioeconomies and integration of the farmer into industrial value chains using the RRI framework, see (Groves et al., 2018).

21. Report, International Conference on Responsible Innovation and Sustainable Agriculture: The Problem of Rice Straw Burning in Punjab, Chandigarh, Punjab, 28–30 November 2016.

22. Report of fieldwork to villages Mehlawala, Bhatala and Jaitu in Punjab 2–5 July 2016.

23. All projects funded by the NWO-MVI programme were required to establish a valorisation panel with potential users of the knowledge produced by the project.

24. Here we draw from the notion of cognitive justice (Visvanathan, 2009): The right of people from diverse knowledge systems to their way of knowing as valid epistemology.

25. Fieldnotes of session 'Technology as Solution' Project Conference in Chandigarh, Punjab, 28–30 November 2016.

26. Jasanoff's actual phrase reads '… how, through the imaginative work of varied social actors, science and technology become enmeshed in performing and producing diverse visions of the collective good' (Jasanoff, 2015, p. 15).

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