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**Publication date**  
2019

**Document Version**  
Accepted author manuscript

**Published in**  
Handbook of Sustainable Innovation

**Citation (APA)**

Cuppen, E., van de Grift, E., & Pesch, U. (2019). Reviewing responsible research and innovation: lessons for a sustainable innovation research agenda? In F. Boons, & A. McMeekin (Eds.), *Handbook of Sustainable Innovation* Edward Elgar Publishing.

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# Reviewing responsible research and innovation: lessons for a sustainable innovation research agenda?

Eefje Cuppen, Elisabeth van de Grift and Udo Pesch

## 1. Introduction

Sustainable development is famously defined as meeting ‘the needs of the present without compromising the ability of future generations to meet their own needs’ (WCED, 1987). This definition has salient moral ramifications, as sustainable development should be fair in terms of the distribution of well-being within and between generations.

The role of social justice as a key condition for sustainable development implies that issues of fairness, justice and legitimacy must be taken into account in innovation and its governance (Jenkins et al., 2016; Stirling, 2009). Balancing the triple Ps of sustainability (people, planet, profit) typically involves trade-offs. What is best in terms of CO<sub>2</sub> reduction is not necessarily the solution that brings the most equal distribution of costs and benefits. Large-scale wind parks contribute substantially to national CO<sub>2</sub> reduction targets, but for some imply negative local impact on the landscape and well-being. Nuclear energy can be used to cover energy demand without CO<sub>2</sub> emissions, but burdens future generations with risks and impacts of nuclear waste storage.

Responsible research and innovation<sup>1</sup> (RRI) has emerged as a policy concept over the past five years as a notion that explicitly aims to put social and ethical issues of research and innovation central to the debate. Although interpretations and definitions of responsible innovation differ, innovation is generally understood to be responsible when it is responding to social needs or oriented ‘towards the “right impacts”’ (Owen, Macnaghten and Stilgoe, 2013), reflexive towards multiple problem definitions and ethical considerations, and characterized by stakeholder inclusion (De Saille, 2015; Owen et al., 2013). RRI has a process and a product side (Von Schomberg, 2013), which means that responsibility is embodied in the product of innovation, as well as its governance process (Correljé et al., 2015). One of the most cited publications defining responsible innovation is by Stilgoe, Owen and Macnaghten (2013; see also Owen et al., 2013). In their paper, they describe four process dimensions of RRI:

- *anticipation* (early-stage consideration of potential societal and ethical impacts and uncertainties);
- *reflexivity* (‘at the level of institutional practice, means holding a mirror up

to one's own activities, commitments and assumptions, being aware of the limits of knowledge and being mindful that a particular framing of an issue may not be universally held' (Stilgoe et al., 2013, p. 1571);

- *inclusion* (deliberation and engagement of stakeholders);
- *responsiveness* ('integration and institutionalization of established approaches of anticipation, reflection and deliberation in and around research and innovation') (Owen et al., 2013, p. 751).

As for the product side of RRI, another widely cited paper written by Von Schomberg (2011, p. 9), states that products should be 'ethically acceptable, sustainable and socially desirable'.

The emergence of RRI should be understood against the backdrop of EU innovation and research policy. Since the Sixth Framework Programme in 2002, there has been a 'gradual intensification of funding for research on informing, communicating with, and otherwise "engaging" the public, in order to promote legitimacy for political decision-making about science' (De Saille, 2015). According to De Saille, the concept first appeared at the level of the Commission in the context of a workshop for invited experts hosted by DG Research on 16–17 May 2011, which was 'a creative attempt to address the growing tension between "innovation" as the driver of jobs and economic growth, and "innovation" as finding socially and environmentally responsible ways to provide for Europe's basic needs'. De Saille (2015) shows how the meaning of the RRI concept changed under pressure of the eurozone crisis. The EU institutions came to frame RRI as a way to speed up innovation in order to pursue immediate economic growth, discarding its moral connotations.

In line with this paradigm that sees innovation as a key driver of European competitiveness, RRI is a concept that has mobilized resources and actors over the past years. Not only on the EU level, but also on the level of national governments in Europe, RRI has been embraced by research funders. In the Netherlands, for example, the National Science Foundation (NWO) has a dedicated programme that funds interdisciplinary research co-funded by industry, in which scientists collaborate with public and private partners to ensure impact. The concept has also been embraced in the UK (the Engineering and Physical Sciences Research Council) and in Norway (the Research Council of Norway) (Thorstensen and Forsberg, 2016).

Academically, the concept of RRI can be seen as 'the end-product of several decades of social science and humanities research in the broad areas of science communication, public engagement, technology assessment, and user-led design' (De Saille, 2015, p. 160). RRI builds on traditions such as science technology studies and ethics of technology, in which the societal risks and (side) impacts of

technology and innovation have been widely studied. Technology assessment (TA) has been developed to foster early engagement and anticipation of societal impacts of science and technology, with various approaches such as real-time TA, participatory TA and constructive TA (Grunwald, 2011; Guston and Sarewitz, 2002; Schot and Rip, 1997). Such approaches were developed from a desire to anticipate negative societal risk and impact of technological developments when these became apparent in fields such as genetic engineering (Grunwald, 2014). Burget, Bardone and Pedaste (2017, p.2) state that 'compared with TA, [RRI] is a broader concept, comprising ethical considerations as well as widespread governance issues'. Another root of RRI can be found in the ELSA (ethical, legal and social aspects of emerging sciences and technologies) approach. Studies in this field have been aiming at providing 'a social and ethical complement to major technology development programs' (Burget et al., 2017). One difference between RRI and its predecessors seems to be that it aims to forefront issues of ethics and societal impact by integrating social science and philosophy research in technology and innovation development, rather than merely having it as an add-on.

As in the case of sustainable innovation, there is no unequivocal definition of responsible research and innovation. As a result, the difference between the two cannot be straightforwardly identified. Some authors see sustainability as one of the dimensions of RRI (Burget et al., 2017; Thorstensen and Forsberg, 2016). Taebi and colleagues (2014) conceptualize responsible research and innovation as innovation that accommodates the plurality of public values during the innovation process. This pertains to public values embedded both in technology (artefacts) itself, but also public values embedded in governance procedures and institutions (Correljé et al., 2015). Sustainability can indeed be regarded as one of these values. However, as we have seen, the *Brundtland Report* definition of sustainable development, which is a general starting point for many scholars in the sustainable innovation field, suggests that social justice is a dimension of sustainability (WCED, 1987). This suggests that sustainable innovation can only be sustainable when it is socially just, that is, responsible.

We do not have the ambition to define the difference between the concepts, as this would be an empty and meaningless endeavour. Rather, we want to understand how scholars deal with the concept of responsible research and innovation in relation to notions of sustainability and sustainable development. We expect that this understanding will help to see the value of work being done under the heading of RRI within the broader context of this book. For this reason, we have conducted a literature review, comprising literature on responsible research and innovation relevant to the field of sustainable innovation.

The research questions that we address are: What features of RRI can be identified that are relevant for sustainable innovation? And how can this support

further development of a sustainable innovation research agenda? The aim of our study guided our analysis towards an identification of those features of RRI that are salient in light of the subject of this book. That is, we deliberately focused on those characteristics that can support a conceptual comparison with other contributions to this book.

In the next section (Section 2) we will discuss the method that we used for the literature review. Based on the overview of articles, we identify six categories of papers, that we used for further analysis. Section 3 presents the results of the literature review for each of the six categories. Section 4 presents an analysis of the characteristics of RRI that are relevant to sustainable innovation based on deeper study of the papers in these six categories. Section 5 concludes the chapter with a discussion of the insights of our analysis of the RRI literature for the wider context of this book.

## **2. Method**

### **2.1 Data Collection and Analysis**

We conducted a structured literature review, which is a systematic approach that guides the identification of the existing body of academic literature (Fink, 2010). A detailed account of our data collection approach can be found in Appendix B. We performed our search in Scopus and Web of Science and, in addition, the online database of the *Journal of Responsible Innovation*. This journal is one of the most prominent outlets for papers in this field, but is not covered in the Scopus and Web of Science database. All papers were stored in an Excel database and double entries were removed. This resulted in a database containing 213 results, for the period until January 7th 2017 (date of the search).

Entries were subsequently coded according to six categories. These categories were inductively identified by going through the entries. After going through the abstracts of 70 entries, a first coding scheme was developed that was then iteratively refined based on reading of new entries. Whenever an abstract was not informative enough, we went to the full paper in order to be able to assign to one category, or in some cases several categories. Most papers were assigned to one category, some (N = 23) were assigned to multiple categories. The six categories will be further illustrated in the next section.<sup>2</sup>

### **2.2 Descriptive Results of the Literature Review**

Figure 8.1 shows the number of publications plotted on a timeline. One can observe a sharp increase from 2013 onwards. When extrapolating the number of publications in 2017 until 6 February (4), it is estimated that this trend will continue.

Most publications are found in the domains of synthetic biology (20) and

nanotechnology (19), followed by health (13), science policy (10), entrepreneurship (10), bioeconomy (9) and energy (7). It is interesting to note here that out of the 164 papers, 44 were published in the *Journal of Responsible Innovation*, a dedicated journal on this topic that was launched in 2014.

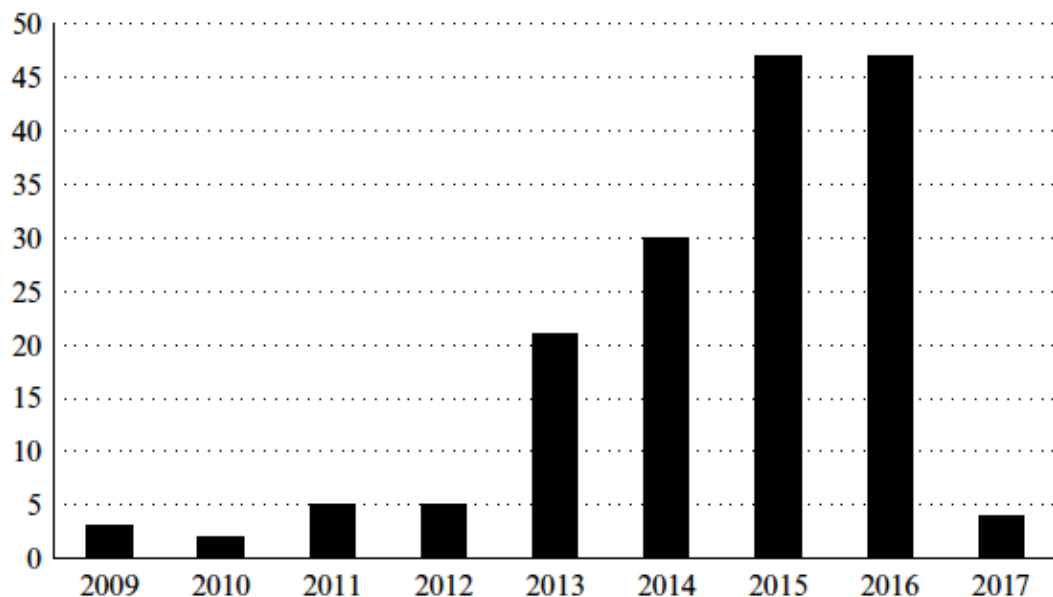


Figure 8.1 Number of publications published between 2009 and 6 February 2017

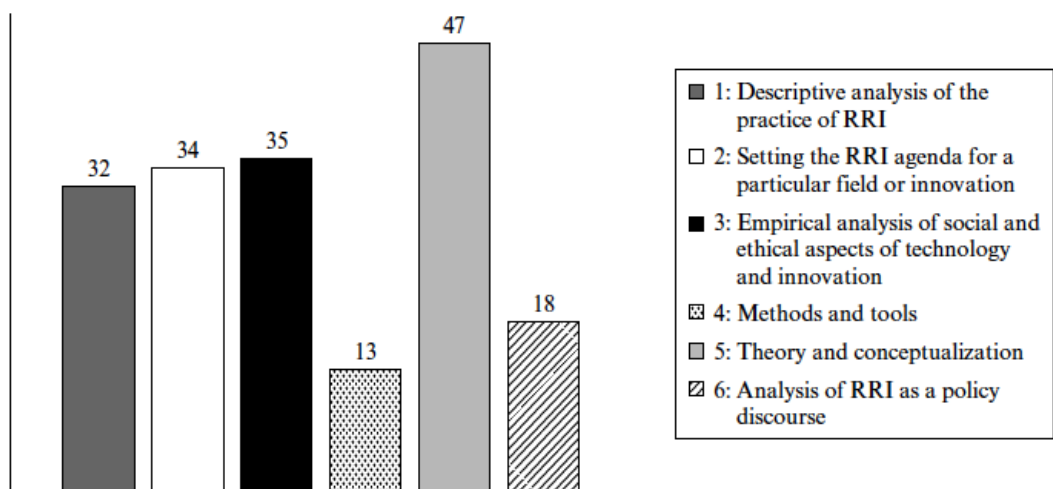


Figure 8.2 Number of publications per category

Figure 8.2 shows what the focus of the published papers is and how papers are distributed over the six identified categories. Most papers focus on theory and

conceptualization of the RRI notion (category 5). Interestingly, the application of such approaches and methods lags behind (category 4).

### **3. Results: contributions per category**

This section expands on the six categories of literature on RRI as identified through our review. For each of the categories a short description will be presented, followed by illustrative examples of these categories to develop an initial idea about the applications and patterns of thought in this emerging field. We will use this to derive some general patterns in Section 4.

#### **Category 1: descriptive analysis of the practice of RRI**

This category includes empirical studies that focus on the practice of, for example, engineers working in R&D labs, entrepreneurs or governance practices and analyse how actors in these practices try to act responsibly.

A first group of papers in this category studies the way in which responsibility is taken up in science. Here, we can think of papers such as De Jong et al. (2016), which presents a media analysis of how neuroscientists communicate to the press, finding that although neuroscientists' aim is to mitigate hypes, 'current reporting is... more likely to enable hype than to mitigate it'. Pandza and Ellwood (2013) studied how nanotechnology research groups deal with the issue of responsibility, concluding that:

[...] researchers and strategists in laboratories experience responsibility at two levels. Firstly, they recognize responsibility as unproblematic if it relates to contexts characterized by low uncertainty of relations between action and impact... Secondly, responsibility is perceived as problematic and ambiguous if relations between action and impact are characterized by high uncertainty. (Pandza and Ellwood, 2013, p. 1112)

Eke, Stahl and Fidler (2015) analyse how information and communications technology (ICT) researchers in the UK address ethics in their research and conclude that ethics reviews are considered relevant by researchers in that domain because it 'is a moral duty, it improves trust for researchers, it is part of risk assessment, it is in compliance with the law and it is a sustainable act' (Eke et al., 2015, p. 28)

The second group involves papers that address RRI in policy fields. Khan and colleagues (2016) focus on research policy and funding in food and health science to analyse how policy actors understand 'innovation', finding that social sciences and the broader public interest are neglected in this understanding. Fisher and Maricle (2015) studied the extent to which decision-makers on nanotechnology in

the USA and the UK ‘explicitly reflected upon societal considerations during priority setting and allocation’, concluding that there was ‘limited integration of societal actors and considerations during research prioritization’.

The third group of papers in this category focuses on industry – for instance, by looking at stakeholder engagement in the Dutch food industry (Blok, Hoffmans and Wubben, 2015), perceptions of responsible innovation in a global asset management company (Asante, Owen and Williamson, 2014), and responsible innovation practices in academic spin-offs (Scholten and Van der Duin, 2015). Findings of these studies appear to be mixed, in some cases responsible practices are found, while in others some clear deficiencies, for instance regarding the uptake of stakeholder engagement, are observed.

### **Category 2: setting the RRI agenda for a particular field or innovation**

The second category comes with strong normative connotations, as it connects ideas about RRI to specific fields of research and innovation and asks itself the question of what should be done in that field in order increase its level of responsibility.

Most papers in this category focus on setting agendas for biotechnology (including synthetic biology) or nanotechnology. Other fields covered are health, finance, human–computer interaction, infrastructure planning and information technology.<sup>3</sup> A first observation is that many of the papers advocate stakeholder inclusion – for example, to identify societal and ethical implications of transgenic fish (Bremer et al., 2015) or to make big data health research more democratic and responsible (Winickoff et al., 2016). A second observation is the recurring claim about uncertainty of technology and innovation and their future impacts, and linked to that, the claimed need for anticipatory governance (Macnaghten, 2016; Miller, 2015; Owen et al., 2009; Özdemir et al., 2011).

### **Category 3: empirical analysis of social and ethical aspects of technology and innovation**

Papers in this category study the social impact and ethical ramifications of new technology and innovation. Papers more or less explicitly use particular RRI frameworks for assessing technology and innovation.

Fields covered in this category are synthetic biology, nanotechnology, bio-economy, geo-engineering, energy, ICT, infrastructure planning and health. Several papers cover more specific technologies such as autonomous vehicles, air conditioning refrigerant, and a specific practice in chicken farming.<sup>4</sup>

A considerable number of the papers in this category use a participatory method (mini-publics, public engagement exercise, stakeholder workshops and so on) to empirically assess societal and/or ethical implications of, for example, synthetic



biology (Bremer et al., 2015; Douglas and Stermerding, 2014), ligno-cellulosic biofuels (Capurro et al., 2015), geo-engineering (Parkhill et al., 2013; Pidgeon et al., 2013), and energy (Groves et al., 2016). Often these methods are applied to analyse the future, for instance in Foley and Wiek (2014) who 'explore distinct nanotechnology innovation and governance models', Read and colleagues (2016) on governance of 'potential co-evolutions of nanotechnology and governance arrangements'. Several studies analyse stakeholders' future visions. Hunsberger (2016) has analysed, for instance, how stakeholders assess the future of bio-energy and the role of *jatropha* (a genus of flowering plant) therein in Kenya.

Another group of papers in this category is based on case studies, mostly in the context of developing countries (such as De Hoop et al., 2016; Kroesen, Darson and Ndegwah, 2015; Setiawan and Singh, 2015). A generic feature of these studies is that they highlight the strong role of local contexts in the distribution of responsibilities.

#### **Category 4: methods and tools for RRI**

Papers found in this category present particular methods or tools to stimulate RRI and/ or report on the actual execution of methods and tools.

Most papers in this category focus on methods or tools to support deliberation and engagement. Arentshorst and colleagues (2014) report on a constructive technology assessment process combined with vision assessment on neuro-imaging applications in health care, and Betten, Roelofsen and Broerse (2013) propose the 'interactive learning and action (ILA) approach' as a methodology to bring societal stakeholders into the development process of synthetic biology. Such approaches have in common that they orient deliberation towards the future, exemplified, for instance, by deliberative scenario workshops (Robinson, 2009), analysis of future imaginaries associated with new technologies (Groves et al., 2016), and hermeneutic analysis of technology visions (Grunwald, 2014). Of a slightly different nature is the paper by Voegtlin and Scherer (2017),<sup>5</sup> which focuses on global governance schemes based on deliberation to contribute to sustainable development. There are papers reporting on specific tools to support deliberation, such as an 'ethical matrix tool' applied to transgenic fish (Bremer et al., 2015) and GM animals (Bremer, Pakki Reddy and Millar, 2013), a software decision support tool for multi-stakeholder global governance of nanotechnologies (Malsch et al., 2015).

Some of the papers focus more specifically on methods that are aimed at transformation of expert practices. Fisher and Maricle (2015, p. 39) provide a survey of what they refer to as 'collaborative approaches to socio-technical integration', to build a 'framework for comparing the forms, means, and ends of collaborative integration'. Flipse, Van der Sanden and Osseweijer (2013, p. 1141) apply so-called midstream modulation – an approach in which an “embedded

humanist” interacts in regular meetings with researchers to engage them with the social and ethical aspects of their work’. Iatridis and Schroeder (2015) discuss a selection of tools that can assist practitioners in implementing RRI in business and industry.

Finally, there are two papers reporting on specific LCA (life-cycle analysis) approaches (Collier et al., 2016; Wender et al., 2014).

### **Category 5: theory and conceptualization of RRI**

This category contains theoretical and conceptual contributions with the intent to further develop or (constructively) criticize RRI concepts.

This is the largest category, which includes a set of papers critically assessing the concept of ‘innovation’ – for example, the way the concept is used in RRI literature (Blok and Lemmens, 2015), the relation between innovation and justice (Ziegler, 2015), or reflecting on the translation of innovation as being traditionally the ‘object of economics and science of business and growth’ (Masclet and Goujon, 2014, p. 69; Miller, 2015).

Also, the concept of ‘responsibility’ is critically assessed in several papers (Lee, 2012; Pellé, 2016; Pellé and Reber, 2016). Several authors point to possible tensions between ‘innovation’ and ‘responsibility’ (such as Stirling, 2016; Tempels and Van den Belt, 2016). Others take a more agenda-building approach, by advocating value-sensitive design of innovation as an approach to achieve responsible innovation rather than ‘mere innovation or the adding of mere new functionality’ (Van den Hoven et al., 2014, p. 75).

Several authors critically reflect on the underlying assumptions and discourse of RRI. Wong (2016, p. 154), for instance, finds it problematic that RRI is now mainly ‘grounded on or justified by liberal democratic values’ and argues that RRI needs to be explored ‘from non-liberal democratic perspectives’. In line with this, De Saille and Medvecky (2016) question the underlying economic growth paradigm and argue that responsible stagnation could be a valuable addition to the discourse on RRI. Van Oudheusden (2014) argues that the way the RRI concept is taken up neglects the importance of politics in and of deliberative processes. Foley and colleagues (2016) argue that ‘current conceptualizations of [RRI] do not address questions of “to what end?” or “how to innovate responsibly?” and develop an innovation governance framework to inform RRI with sustainability principles. Anticipation, as one of the dimensions of RRI, is also critically reflected upon (Guston, 2013). Nordmann (2014) questions, for example, to what extent anticipation is actually possible, since it is always based on the world as we know it today. Wickson and Carew (2014) point to the interpretative flexibility of the RRI concept, which they find problematic, and argue that there is a need for articulation of quality criteria and indicators to evaluate RRI.

Furthermore, there are papers that apply the RRI concept to the context of industry and business and discuss it from a theoretical perspective instead of having an empirical study as its starting point. These papers, for instance, discuss the ethical and legal context of technology commercialization (Hemphill, 2016), and develop frameworks for RRI in firms (linked to corporate social responsibility) (Nieuwkamp, 2010; Paredes-Frigolett, 2016) and for project management of megaprojects (Tinoco, Sato and Hasan, 2016).

### **Category 6: analysis of RRI as a policy discourse**

This category includes papers that discuss RRI as a policy concept, paradigm, or discourse and traces its emergence.

For instance, Arniani (2016) and De Saille (2015) explore the processes through which RRI has been incorporated into Horizon 2020 as a policy framework for the European Research Area. Arnaldi and Gorgoni (2016) explore the political-economic context and discuss how its characteristics relate to neoliberalism and its understanding of responsibility. Van Oost and colleagues (2016) explore how policy implications can be derived from five future scenarios of transformed research and innovation (R&I) systems. The aim of their paper is to provide an outlook on strategic policies capable of facilitating or moderating these transformative changes in research and innovation practices. There are also papers that describe the emergence of the concept in a particular science field – for instance, in the context of synthetic biology (Li, Owen and Simakova, 2015) and nanotechnology (Laird & Wynberg, 2016).

Papers like Eizagirre (2016) and Rip (2016) present a broader reflection on the underlying narrative of RRI, claiming that it reflects the tale of the new clothes of the emperor, or even that there may not be an emperor (yet). Likewise, Ribeiro and colleagues (2017) see RRI as a buzzword, which, however, has the capacity to figure as a mobilizing concept. Macnaghten and colleagues (2014) discuss the discourse of RRI from a cross-cultural perspective.

## **4. Analysis: characteristics and assumptions of RRI research**

Above, we have made an overview of literature on RRI. On the basis of this overview, we will now distil some key characteristics, distinctive patterns, as well as implicit assumptions of RRI. The aim of this analysis is to draw out the analytical themes cross-cutting the six categories that are relevant for a comparison between the notions of RRI and sustainable innovation.

### **4.1 A Focus on Process**

The first category identified in our literature overview concerns papers that analyse

the practice of RRI – for example, scientists in R&D labs. Browsing through the titles of these papers, one observes the focus on verbs and processes instead of nouns and products. Indeed, a closer investigation confirms that a common thread in these descriptions of the practice of RRI is that the authors focus on the process of innovation and research. Along different industrial sectors and academic disciplines, how and to what extent certain normative conditions are taken into account in this process is studied. This pattern indicates that the focus of RRI research is on the process, not so much on the outcome. Also, in the other categories, one can observe the emphasis on the process of innovation – for example, by elaborating tools and approaches for engagement (category 4). This observation is shared by Thorstensen and Forsberg (2016), who state that the product side of RRI remains less discussed in RRI literature (also see Schroeder et al., 2016, p. 178).

This emphasis on process deviates from the much-cited definition of RRI of Von Schomberg (2013), which not only highlights the ‘acceptability, sustainability and societal desirability’ of the process, but also of the outcomes of innovation processes. Instead, the focus on the process fits very well with the ‘dimensions of RRI’ as introduced by Owen and colleagues (2013, p. 755; see also Stilgoe et al., 2013), as these dimensions – anticipation, reflection, inclusion and responsiveness – relate directly to the process of innovation. This suggests that even though both papers have a comparable number of references in Google Scholar (slightly over 300 each at the time of writing), the approach presented by Owen and colleagues (2013) finds more follow-up. A possible explanation for this trend is that a lot of RRI literature addresses science and research in emergent fields such as nanotechnology and synthetic biology, which have fundamentally uncertain outcomes. As such, the emphasis on process seems justified. It is simply not productive, or even ethically desirable (Nordmann, 2014) to assess the desirability of outcomes, if these are fundamentally unknown. Instead, the developers of new knowledge and new technology should be given the tools to reflect and anticipate on the uncertainties that are created by their work (Guston, 2014).

At the same time, one may argue that this focus on process, together with an emphasis on science and research, ignores the fact that outcomes are not the end of a research and innovation process. Rather, research and innovation results in outcomes that can be considered intermediate outcomes in a wider socio-technical process in which products and impacts of innovation are evaluated, (re)interpreted and become input for new innovation processes. This wider process view on innovation suggests that more attention to (intermediate) outcomes, as well as to innovation, would benefit RRI’s understanding of how responsibility can be conceptualized in terms of the socio-technical dynamics of innovation processes.

Traditional accounts of responsibility cannot be straightforwardly incorporated in

innovation as these are in conflict with the very nature of innovation as a process with an undefined outcome (Owen et al., 2013, p. 756). Responsibility usually pertains to the ex post assessment of actions or decisions (Pesch, 2014), which implies that the notion must be reframed before it can be applied to research contexts. According to Owen et al. (2013), their dimensions of RRI are suited for and as such allow to 'bring society into' innovation. To pursue its goals, RRI builds on existing approaches and frameworks for stakeholder involvement. Here we may think of constructive technology assessment (Arentshorst et al., 2014), upstream engagement (Capurro et al., 2015), midstream modulation (Bremer et al., 2015; Flipse et al., 2013) and other participatory methods of decision-making that are also familiar in research on sustainable innovation. However, RRI does not pertain to a mere relabelling of established frameworks, as the focus on responsibility adds normative elements to these methods. Approaches to stakeholder involvement have traditionally focussed on interests, strategies and resources on the one hand and world views, expectations, and problem definitions on the other hand (Rowe and Frewer, 2000; Van Asselt Marjolein and Rijkens-Klomp, 2002), but they have not paid attention to the issues that bear an ethical connotation (Roeser and Pesch, 2016).

At the same time, it is not directly clear how ethical considerations are to be taken up in innovation practices, as the uncertainty of future outcomes contrasts with the backward- looking and static nature of most ethical inquiry. Indeed, our literature review reveals that there are different entrance points and proposals on how to bring in ethics. We have seen ethics reviews and other formalized arrangements to ensure that moral considerations are taken into account, while other authors emphasize the forward-looking responsibilities of individual agents involved in innovation themselves. Felt (2017) has labelled this contrast as one between 'new bureaucracies of virtue' and 'response-able practices'. Probably both orientations will continue to be part of the RRI discourse; after all, there will always be a tension between the need to conform to pre-given normative conditions while acknowledging the fundamentally open-ended nature of innovation.

The difficulty to rearticulate moral considerations in light of innovation raises some questions about precisely how RRI approaches will differ from earlier frameworks such as CTA. At this moment, we can only stress that RRI explicitly adds normative considerations as significant to the quality of innovation processes, recruiting a wide range of aspects that could or should be taken into account.

To some extent, the orientation towards the process of innovation contrasts with the focus in literature on sustainable innovation; sustainability after all is a goal that needs to be pursued. This does not mean that the process of sustainable innovation is not attended to, but that the process has to effectively serve the goal of sustainability. By giving more attention to the process of innovation, a more balanced take on technology development, in which social responsiveness and

sustainability are both addressed, may emerge.

#### **4.2 Changes *within* the System, not of the System**

RRI research features participatory methods as one of the main methods to allow the identification of societal values and moral concerns that need to be taken into account in innovation practices. In the literature, we see a pattern that this involvement of stakeholders serves an informative (or even instrumental) role. The reason for this pattern is that RRI invites actors from outside of innovation practices to express their values, concerns and interests regarding new technology development, while this development itself is still primarily seen as an activity of experts. A critical evaluation of this situation is that the establishment of interaction with outsiders may motivate innovators to become more responsive to society, without having to change the institutional context in which innovations are pursued.

With that, RRI reproduces a rather conventional role division between innovators on the one hand and users and affected parties on the other hand. It is up to the innovators to enlarge their mental and moral scope while creating new knowledge and new technologies. This means that even though existing innovation practices are improved by accounting for responsibility, they are not transformed. It is particularly the critical literature on RRI found in our sixth category that hints at this seemingly conformist nature. For instance, Van Oudheusden (2014, p. 68) finds that the frameworks of RRI 'largely ignore questions about the politics in deliberation [and] forsake questions about... the institutional uptake of deliberative engagements'. The tension between responsible innovation and the political pursuit for economic growth is also noted by authors such as Eizagirre (2016), Masclet and Goujon (2014), and De Saille (2015).

The maintenance of a conventional role division points at a salient difference between sustainable innovation research and RRI research. The transformation towards a sustainable society is often portrayed in terms of radical changes in the main institutional frameworks that reproduce unsustainable practices. Without such changes, unsustainable decisions about technological development will be repeated, hindering sustainable progress (Carrillo-Hermosilla, Del Río and Könnölä, 2010; Loiseau et al., 2016). In the context of sustainable innovation, stakeholder involvement is often portrayed explicitly to contribute to a system's change and as such it fulfils another role than is given in RRI.

This means that if their intrinsic logic is stretched, the frameworks of sustainable innovation and RRI become incompatible. Whereas sustainable innovation may require radical changes in political and economic arrangements, the discourse on responsible innovation assumes the continuation of these arrangements. This incompatibility is somewhat manifest in RRI approaches that see responsibility as subservient to economic growth and industrial success or approaches that unreflectively endorse ethical checklists. Having said that, in most cases,

responsibility and sustainability are seen as congruent. What the discourse on sustainable innovation can learn from RRI is that the pursuit of sustainability should be accompanied by moral questions about justice and responsibilities. Conversely, what RRI can learn from the discourse on sustainable innovation is that responsible innovation may require system change, or at least critical reflection on the institutional, economic and political arrangements in place, including the politics involved in the allocation and attribution of responsibilities. This lesson is underlined by several observations that show societal contestation over institutional arrangements, such as a declining trust in institutions, crisis in democratic governance, and critiques on the legitimacy of public participation. These observations suggest that being responsive to societal needs, which is a key aim of RRI, implies a rearrangement of institutional structures.

## **5. Conclusion and discussion**

We started this chapter by sketching the emergence of the RRI concept in EU research policy, as the backdrop against which the literature on RRI should be understood. This shows the close interaction between policy and research agendas, and suggests that, just like notions such as 'sustainable development' and 'sustainable innovation', RRI serves as a boundary object (Star and Griesemer, 1989): 'a sort of arrangement that allows different groups to work together without consensus' in a 'shared space' (Star, 2010, pp. 602–3). Ribeiro and colleagues (2017, p. 81) refer to RRI as a 'buzzword', 'becoming a focus of concerted experimentation in many academic circles'. Indeed, concepts such as RRI, sustainable innovation (and currently, for instance, also circular economy) that mobilize resources and shape policy and research directions, are very much sensitive to trends. There seems to be only a temporary space in which such concepts can effectively function as boundary objects.

Based on the findings from our literature review we can identify three issues that seem rather specific to RRI and that can be used to further shape a sustainable innovation research agenda. First, RRI has an explicit focus on the ethics of innovation. Public values related to innovation – its process and outcomes – are treated explicitly as ethical aspects of that innovation. A focus on public values allows for making explicit the complex normative dimensions of sustainable innovation. That is, in some disciplines, sustainable innovation is primarily understood in terms of environmental and ecological values. An RRI perspective on sustainable innovation helps to identify the range of public values involved, including substantive values such as safety, environmental health, efficiency, as well as procedural values, such as fairness, transparency and accountability (Dignum et al., 2016). In addition, and more critical, it helps to articulate value trade-offs that are inherent to sustainable innovation. RRI calls for reflexivity in terms of how such value trade-offs are made.

This brings us to the second issue. We observed that there is a strong process orientation in the RRI literature. Although the lack of orientation on outcomes can be considered a weakness (see Section 4), it does point us to the importance of process for identifying, considering, weighing and reflecting upon diverse values (and their trade-offs) involved in sustainable innovation. The four process dimensions of RRI identified by Stilgoe and colleagues (2013) – anticipation, reflexivity, inclusion and responsiveness – suggest how the innovation process allows for deliberation of ethical considerations and dilemmas. With that, it allows for a more explicit dialogue on the normativity of sustainable innovation. Within the field of sustainable innovation different schools of thought exist, each with its own, often implicit, normative underpinnings. An RRI perspective can help to make the normativity involved in sustainable innovation more explicit. This is especially relevant since the normative underpinnings of different schools of thought are sometimes incompatible (see Loiseau et al., 2016).

As a boundary object, RRI may bring together contrastive practical and theoretical starting points. For instance, De Saille (2015), points at the internal tension between responsibility and innovation. On the one hand, there is ‘a growing demand for responsible models of research and innovation, and on the other hand, [there is a demand for scientific-technological activity] implemented for macroeconomic results’ (Eizagirre, 2016, p. 815). In other words, the course of innovation should not be intervened because of the need to create a competitive business climate, while RRI suggests that innovation trajectories should be subjected to a certain level of intervention. More explicit reflections on the desirability and possibility of intervention will contribute to the field of sustainable innovation. Another tension that can be brought in here refers to the structure–agency debate. Whereas studies on sustainable innovation appear to have predominantly followed structuralistic accounts, especially looking at the role of ‘systems’ in either the obstruction or the acceleration of sustainable technologies, questions of responsibility steer scientific studies towards agency by emphasizing the role of individuals (such as engineers working in R&D labs developing innovations) in shaping innovation. The introduction of agency may create a broader understanding of innovation, allowing it to become both more sustainable and more responsible.



## Notes

1. We use the label 'responsible research and innovation' throughout the chapter, though the notion of 'responsible innovation' is also used by some authors.
2. Though our categorization may differ, given our research question and the interpretative character of our analysis, the findings largely corroborate with other surveys on RRI, such as Ribeiro, Smith and Millar (2017) and Timmermans (2017).
3. These topics can be connected to the following papers: biotechnology: Asveld, Ganzevles and Osseweijer (2015), Bremer et al. (2015), Keeler and Foley (2015), Macnaghten (2016), Miller (2015), Thomas (2015); nano- technology: Foley, Bernstein and Wiek (2016), Grunwald (2012), Owen et al. (2009), Schroeder et al. (2016), Timmermans, Zhao and Van den Hoven (2011), Wickson and Forsberg (2015); health: Chalmers et al. (2014), Özdemir, Faraj and Knoppers (2011), Pavlidis et al. (2016), Winickoff, Jamal and Anderson (2016); finance: García Fronti and Castro Spila (2013); human–computer interaction: Grimpe, Hartswood and Jirotko (2014); infrastructure planning: Ravesteijn et al. (2014); and information technology: Van de Kaa (2014).
4. These topics can be connected to the following papers: synthetic biology: Bremer et al. (2015), Douglas & Stermerding (2014); nanotechnology: Foley and Wiek (2014), Grunwald (2012), Read et al. (2016), Robinson (2009); bio-economy: Capurro et al. (2015), De Hoop, Pols and Romijn (2016), Lynch, Klaassen and Broerse (2017), Shortall, Raman and Millar (2015); geo-engineering: Parkhill et al. (2013), Pidgeon et al. (2013), Stilgoe (2015); energy: Dignum et al. (2016), Groves et al. (2016), Setiawan and Singh (2015); ICT: Carsten Stahl (2011); infrastructure planning: Ravesteijn, Liu and Yan (2015), Song and Ravesteijn (2015); health: Arentshorst et al. (2014), Demers-Payette, Lehoux and Daudelin (2016). Several papers cover more specific technologies such as: autonomous vehicles (De Bruin, 2016), air condition refrigerant (Wodzisz, 2015), and a specific practice in chicken farming (Bruijnijis et al., 2015).
5. The paper by Voegtlin and Scherer was first published online in 2015, but was published in the *Journal of Business Ethics* in 2017.

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## APPENDIX A

Table 8A.1 Overview articles included in review, per coding category

Category 1 Descriptive Analysis of the Practice of RI (N = 32)		Category 2 Setting the RI Agenda for a Particular Field or Innovation (N = 34)		Category 3 Empirical Analysis of Social and Ethical Aspects of Technology and Innovation (N = 35)		Category 4 Methods and Tools (N = 13)		Category 5 Theory & Conceptualization (N = 47)		Category 6 Analysis of RRI as a Policy Discourse (N = 18)	
Asante et al.	2014	Asveld et al.	2015	[No author name]	2015	Ajami et al.	2016	Blok & Lemmens	2015	Arnaldi & Gorgoni	2016
Blok et al.	2015	Beekman & Dagevos	2013	Arentshorst et al.*	2014	Arentshorst et al.*	2014	Burget et al.	2017	Amiani	2016
Bos et al.	2014	Bessant	2013	Bremer et al.*	2015	Betten et al.	2013	Calvert & Frow	2013	De Saille	2015
Ceccaldi, 2016	2016	Bremer et al.	2015	Brian	2015	Bremer et al.*	2015	Cuijpers et al.	2014	Eizaguirre	2017
De Jong et al.*	2016	Chalmers et al.	2014	Bronson	2015	Bremer et al.	2013	De Saille & Medvecky	2016	Eizaguirre	2016
De Jong et al.	2015	Davis & Laas	2014	Brujinis et al.	2015	Collier et al.	2016	Deblonde	2015		
Eke et al.	2015	Garcia Fronti & Castro Spila	2013	Bruin	2016	Fisher et al.	2015	Di Giulio et al.	2016	Hagen	2016
Fisher and Maricle	2015	Grimpe et al.	2014	Capurro et al.	2015	Flipse et al.	2013	Foley et al.	2016	Laird & Wynberg	2016
Flipse et al.	2014	Grunwald*	2012	Carsten Stahl	2011	Groves et al.*	2016	Ganzevles et al.	2014	Lee	2012
Flipse et al.	2013	Hurlbut	2015	De Hoop et al.	2016	Iatridis & Schroeder	2015	Grunwald*	2014	Li et al.	2015
Murphy et al.*	2016	Keeler & Foley	2015	De Jong et al.*	2016	Ikonen et al.	2015	Guston	2013	Macnaghten et al.	2014
Navickas & Kontautiene	2013	Macnaghten*	2015	Demers-Payette et al.	2016	Malsch et al.*	2015	Guston	2014	Murphy et al.*	2016
Halme & Korpela	2014	Macnaghten & Carro-Ripalda	2015	Dignum et al.	2016	Robinson*	2009	Hemphill	2014	Owen et al.	2013
Höjer et al.	2012	Macnaghten*	2016	Douglas & Stermerding 2014	2014	Voegtlin & Scherer	2017	Hemphill	2016	Ribeiro et al.	2017
Iyer & Soberman	2016	Malsch et al.*	2015	Foley & Wiek	2014	Wender et al.	2014	Iatridis & Schroeder	2015	Rip	2016
Khan et al.	2016	Miller	2015	Groves et al.*	2016	Wright et al	2011	Jellema & Mulder*	2016	Rip & Van Lente	2013
Kimmel et al.	2016	Owen et al.	2009	Grunwald*	2012	Grunwald*	2014a	Kroesen et al.*	2015	Van Oost et al.	2016
Li et al.	2015	Özdemir et al.	2011	Hunsberger	2016	Jellema & Mulder*	2016			Van Oudheusden	2014
										Van Geenhuizen & Ye	2015
Low	2017	Özdemir et al.	2014	Kroesen et al. *	2015			Lenoir	2016		
Magro-Montero	2009	Pavlidis et al.	2016	Lynch et al.	2016			Maasen	2015		
Mampuy & Brom	2015	Petráite & Ceicyte	2014	Macnaghten *	2015			Masclat & Goujon	2014		

Pandza & Ellwood	2013	Ravesteijn et al.	2014	Macnaghten*	2016	Miller	2015
Rip & Van Lente	2013	Scholten & Blok	2015	Parkhill et al.	2013	Nieuwkamp	2010
Scholten & Van der Duin	2015	Schroeder et al.	2016	Pidgeon et al.	2013	Nordmann	2014
Spena & De Chiara	2012	Schroeder & Ladikas	2015	Raman et al.	2015	Paredes-Frigolett	2016
Eke et al	2015	Thomas	2015	Raman	2015	Owen et al	2013
Stemerding	2015	Timmermans et al.	2011	Ravesteijn et al.	2015	Pellé & Reber	2016
Sykes & Macnaghten	2013	Van de Kaa	2014	Read et al.	2016	Pellé	2016
Turcanu et al.	2016	Van den Hove et al.	2012	Robinson*	2009	Pesch	2014
Van Geenhuizen & Ye*	2014	Wickson & Forsberg	2015	Setiawan & Singh	2015	Pesch & Ravesteijn	2013
Voeten et al.	2015	Wiek et al.	2016	Shortall et al.	2015	Stahl & Brem	2013
Voeten et al.	2014	Winickoff et al.	2016	Som et al.	2010	Stilgoe*	2015
Williams	2013	Vogt*	2016	Song & Ravesteijn	2015	Stilgoe et al.	2013
		Kay*	2016	Stilgoe*	2015	Stirling	2016
				Wodzisz	2015	Tempels & Van den Belt	2016
				Foley et al*	2016	Thorstensen & Forsberg	2016
						Tinoco et al.	2016
						Turk	2016
						Tyl et al.	2011
						Van Geenhuizen & Ye*	2014
						Van den Hoven.	2013
						Van Oudheusden	2014
						Voegtlin & Scherer*	2017
						Wender et al.	2014
						Wickson & Carew	2014
						Wigboldus et al.	2016
						Wong	2016
						Ziegler	2015
						Kay*	2016
						Vogt*	2016
						Čečiūyte & Petraite	2014

Note: \* = multiple categories assigned.

## APPENDIX B

To retrieve our data, we took the following approach. In Scopus, we used the following search string: ((TITLE-ABS-KEY('responsible innovation') OR ('responsible research and innovation') AND TITLE-ABS-KEY (sustainability OR 'sustainable innovation' OR sustainable)). This delivered 66 results (7 February 2017). In Web of Science we used the search string ('responsible innovation' OR 'responsible research and innovation') AND TOPIC: (sustainability OR 'sustainable innovation' OR sustainable) (from Web of Science Core Collection). This delivered 38 results (date of download: 7 February 2017). In the *Journal of Responsible Innovation*, we searched the following keywords: 'Sustainability' (57 results); 'Sustainable innovation' (two results); 'Sustainable' (62 results) (date of download: 6 February 2017). Figure 8A.1 represents a flow chart of this process.

After the process of data collection was finished, abstracts of all entries were read to decide whether the entry was relevant for the review or not. This led to another round of selection that produced a final set of 164 publications (see Appendix A for overview). Inclusion of an entry was based on the following criteria:

- It should be clear from the abstract that there is a focus on the social and ethical impacts of innovation (or RRI mentioned explicitly).
- Papers that are not primarily about innovation, innovation processes or science and research policy are excluded (for example, papers about science education on RRI-related aspects, or RRI and sustainability education).
- Book reviews and introductions to volumes are excluded (but literature reviews are included).

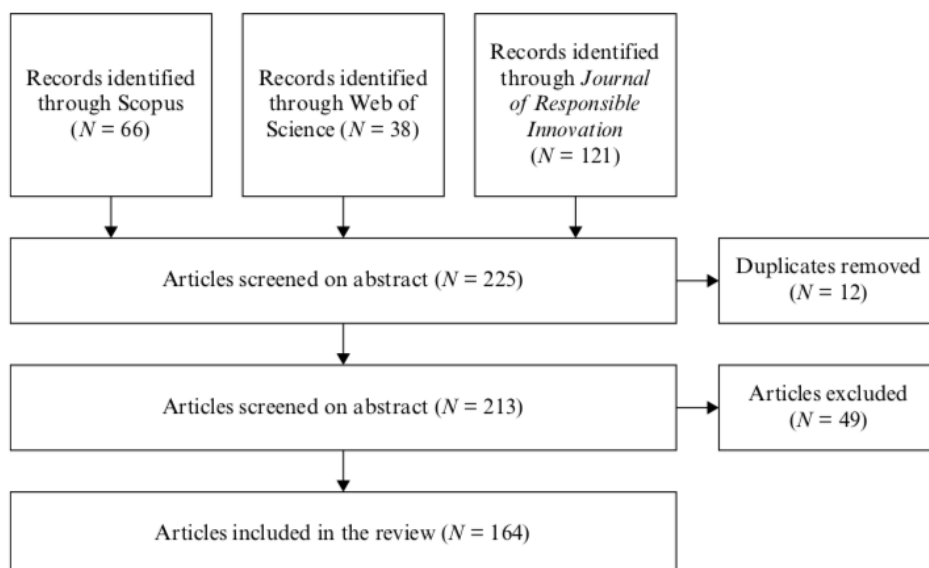


Figure 8A.1 Flow diagram of literature selection and coding procedure