



Conceptualizing Responsibility in Food Research and Innovation to Promote Healthy and Sustainable Food Systems

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Responsibility is crucial to governance and key to achieving legitimacy within complex systems, yet there is limited attention to how it should be conceptualized within the context of food research and innovation (R&I). Understanding how diverse stakeholders in food R&I conceptualize responsibility is vital because it shapes the way problems are identified, goals are set and solutions are put in place. We report on empirical research with diverse stakeholders across Europe to understand and map the dimensions of responsibility for food R&I to support healthy and sustainable food systems. Semi-structured interviews were conducted with 32 stakeholders working in R&I in the cutting-edge domains of: cultured meat as a substitute for livestock meat; new crop breeding of potatoes; and a new approach to obesity reduction that focuses on weight acceptance. Drawing from the empirical evidence collected, we developed a classification system that reflects various conceptualizations of stakeholders' responsibility for food R&I to support healthy and sustainable food systems. Our thematic analysis revealed four overlapping rationales of responsibility—accountability, impact, reflexivity, and responsiveness, and characterized them in terms of: who the researcher is responsible to; whether the assessments of responsibility focus on R&I processes or impact; whether responsibility implies societal engagement; and how responsibility is assessed—retrospectively or prospectively. The article provides a basis for systematic application of these criteria to the specific instances of food R&I governance and for future joint decisions, about the ways to allocate responsibilities.

Keywords: research and innovation, responsibility, accountability, food system, impact, sustainability, obesity, cultured meat

INTRODUCTION

The modern food system is a globalized, multi-sector and inter-dependent network, structured as a complex web of private and public partnerships of diverse actors such as transnational corporations, international agencies, interest groups, non-governmental and civil society organizations, and national, regional and local governments (Barling, 2008; Friel, 2017). Governance of the food system network is enabled via international and national trade and investment agreements and a plethora of regulatory, fiscal, and voluntary (self-regulatory) approaches that go beyond state-led regimes, increasing its segmentation and fragmentation (Biermann and Pattberg, 2008; Kraak et al., 2014). It is driven by the supply-push factors that prioritize efficiency, traceability and

resource allocation and the demand-pull factors of consumer perceived private benefits, with market forces taking over many of the functions previously seen as a state prerogative (Kraak et al., 2014; Swinburn et al., 2015). However, the contribution of the existing food system to the global climate and health threats requires a re-orientation of the system to go beyond the narrow focus on productivity and cost-effectiveness (Whitmee et al., 2015; Lawrence and Friel, 2019), toward alternative sets of drivers such as resilience, social justice and sustainability (Ingram, 2011; Niles et al., 2018). There is little evidence for the effectiveness of strategic public-private partnerships, although they have ostensibly had a limited success in tackling global public health nutrition and sustainability challenges (Kraak et al., 2014; Swinburn et al., 2015). Key contributing factors are insufficient clarity about how responsibility is allocated within such complex networks of actors, and lack of accountability frameworks through which they are governed (Kraak et al., 2014). Indeed, governance implies allocation of responsibility (Löfmarck et al., 2017), and transparent governing of food system networks requires clarity about how responsibility is conceptualized and enacted (Kraak et al., 2014; Swinburn et al., 2015). Within the current paper we report on a study which explores the conceptualizations of responsibility within the context of food research and innovation (R&I), as a specific domain of food system operation. Our purpose was to conduct empirical research with a diverse set of stakeholders across Europe to understand and map the rationales of responsibility for food R&I to support healthy and sustainable food systems. Drawing from the empirical evidence collected, we develop a classification system that reflects various conceptualizations of stakeholders' responsibility for food R&I to support healthy and sustainable food systems.

In the sections that follow, we first provide an overview of the current efforts to understand responsibility in the context of the globalized food system. We then explore conceptual developments of the notion of responsibility from the social science perspective before we set the scene for the current empirical study.

Conceptualizations of Responsibility in Food System Governance Literature

There are relatively few papers discussing responsibility within the food systems governance context. Responsibility within the modern food system has historically been discussed in terms of causal responsibility for the outcomes of “irresponsible” action (e.g., obesity); the prevailing narrative has focused on personal responsibility for healthy and sustainable choices, shaping the policy responses toward prioritization of private initiatives and self-regulatory solutions (Kraak et al., 2014; Roberto et al., 2015). The individualistic conceptualizations of responsibility that focus on who “caused” the problem, obfuscate the inter-dependencies within the complex food system, and cannot guide governance decisions about future problems arising out of the food system's inherent uncertainties. More recent frameworks have recognized that such approaches have resulted in governance gaps that have led to the excessive influence of the food industry and the erosion

of the stronger mechanisms controlling for undue influence of vested interests over food policy (Mindell et al., 2012).

An alternative conceptualization of responsibility has emerged from a small body of literature that examines governance processes within this complex and diffused network of actors (e.g., Kraak et al., 2014; Swinburn et al., 2015; Hospes and Brons, 2016; Friel, 2017; Lawrence and Friel, 2019). A recent United Nations System Standing Committee on Nutrition (UNSSCN) report maps this complex network and contends that, since no one sector has responsibility for nutrition, clarifying actor responsibility for nutrition and developing effective mechanisms to hold all actors accountable for actions that impact nutrition remains a task critical to the development of workable governance mechanisms (Friel, 2017). Kraak et al. (2014) developed a framework of accountability of all actors within the complex food system in order to enable transparent, open and fair governance. The authors distinguished between responsibility and accountability. They defined the former as a commitment or an obligation imparted upon an individual or a group based on social, moral and/or legal standards, and accountability as an ability of different actors within the system to hold each other to account, which is ultimately about “how and why decisions are made, who makes decisions, how power is used, shared, and balanced, whose opinions are important, and who holds whom to account” (Swinburn et al., 2015, p. 2,535). Governance was defined as different behaviors and activities (“steps”) that enable the process of “accounting,” enacted through taking the account (evidence collection); sharing the account (dissemination, communication of evidence); holding the account (carrying out actions) and responding to the account (taking remedial actions). Accountability, in this articulation, is concerned with the ability to justify decisions and the ex-post evaluation of the reasons for action, which is particularly relevant for governing distributed networks where there is no single authority imposing sanctions for the system's transgressions. Swinburn et al. (2015) developed this framework further by identifying the policy levers that could be used to ensure accountability within these four steps and suggested regulatory and non-regulatory approaches through which each actor within the system can hold the other to account.

It has often been commented that implementation of governance driven by accountability mechanisms can have an unfortunate effect of obscuring judgments about ethical responsibility by prioritizing only those values which can be measured and accounted for (Collini, 2017), a problem particularly apposite in the context of food innovation and research. For instance, the drive toward accountability in food and health research and innovation has inconspicuously led to prioritization of the innovations that have tangible, measurable economic benefits (Khan et al., 2016). Furthermore, because an accountability framework is primarily concerned with backward responsibility, an ex-post accounting of the web of decisions, it ignores those responsibilities for which roles, decisions and future consequences are more difficult to allocate. Achieving sustainability (environmental, social, and economic) is marred by uncertainty not only about how to organize governance of sustainable food system, but also about the values by

which to judge governance decisions (Partzsch, 2011). Sharpe and Barling (2019) illustrated this through their study of stakeholders from various food supply chain organizations about their conceptualizations of the kind of responsibility which requires re-orientation toward greater social sustainability. Their study showed that, whilst re-orientation of business toward sustainability is recognized by stakeholders as “the right thing to do” (a moral imperative), practically, it was difficult to implement. The perceived requirement for more pragmatic focus on calculations and programmatic focus on economic efficiencies means that the accountability framework prioritizes those elements of business activities that can be more easily quantified and accounted for. In short, simply focusing on accountability as a means of governing global food systems may not be enough to achieve a lasting shift toward sustainability. New conceptualizations of responsibility to influence governance within a non-linear food system characterized by uncertainties and volatility are needed (Pereira and Ruysenaar, 2012; Clancy, 2014).

The concept of responsibility recently discussed within the context of R&I emphasizes wider conceptualization of responsibility within the overall innovation process. The concept of Responsible Research and Innovation (RRI, Von Schomberg, 2011) questions the accepted roles and responsibilities of all research process stakeholders in relation to both R&I process and outcomes. It defines responsibility as ethical responsibility achieved through engagement at all stages of the R&I process with the impacts and outcomes of innovation as well as the broader societal values and expectations of R&I (Owen et al., 2012), calling for all innovators to be responsive to these in their design process, anticipating, reflecting and responding to emerging challenges. This is a future-oriented notion of responsibility (ex-ante), focused on aligning current practices with the value expectations and societal representations of a desirable future. The definition of RRI is rather open-ended (Zwart et al., 2014) and its delineation from the other, aligned concepts such as ELSA (ethical, legal, and social aspects of emerging sciences and technologies) and Precautionary Principle, is poorly articulated. Furthermore, a common criticism of the concept of RRI is that, in the absence of frameworks specifying dimensions of responsibility and how it should be translated into specific innovation process, it lacks broader applicability (Burget et al., 2017; Timmermans et al., 2017). Despite a growing body of empirical studies exploring the application and implementation of RRI in specific R&I domains, there is limited empirical work on responsibility in food R&I.

Defining Responsibility

Responsibility is a multifaceted construct that subsumes the considerations of a responsible actor (their motivations, intentions, identities), their actions, and the rules or norms through which these actions are judged. Pellizzoni (2004) developed a conceptual framework of responsibility through which responsibility can be more clearly articulated and assessed. The framework combines two dominant dimensions of responsibility: answerability (an ability to justify one's actions) and imputability (causal attribution of action to

someone as its actual author). Answerability largely depends on whether we are focused on understanding the past actions (ex post) or on developing a set of rules that help respond to future challenges (ex ante). Imputability can vary by the degree of uncertainty surrounding actions, or the absence or presence of knowledge on which to base causal attributions of actions. Pellizzoni argued that responsibility can be categorized along these two dimensions through which we come to understand how the relationships of responsibility are organized within society:

- Accountability focuses on justifying past actions in the context of high uncertainty (high uncertainty ex-post); it requires identification of the means of accounting for actions, typically through accepted standards and codes of conduct.
- Liability is relevant in the contexts characterized by clearly specified rules according to which past action are to be judged (high certainty, ex-post); it requires unequivocal compliance with these rules.
- Care is a type of responsibility driven by the concern for doing the right thing which is clearly understood and socially accepted; it is oriented toward the future well-being of that which is cared for (high certainty, ex-ante).
- Responsiveness is oriented toward future goals characterized by uncertainty; responsibility is enacted through being “responsive” to the changing environment (high uncertainty, ex-ante).

Different dimensions of responsibility can be elaborated in relation to other concepts crucial to governance of non-linear systems characterized by uncertainty and diversity of actors within the complex systems such as the global food system (Termeer et al., 2018; Simon et al., 2019): trust, legitimacy, and power.

Trust is a relational construct which, like responsibility, is closely linked with the challenge of uncertainty: it is an attitude of confidence in the future outcomes based on uncertain or imperfect current information and has a psychological role in reducing social complexity and uncertainty (Luhmann, 1979; Simmel and Bottomore, 2004). Certain types of responsibility—such as care and responsiveness—are grounded in the relationships of trust, as they are based on a kind of faith that the trustor (the person with responsibility) has the best interest of the trustee in mind. Accountability arguably functions within the contexts in which the highly diffused and complex web of actors cannot be supported through the relationships of trust. Accountability enables checks and balances within the network, which allow system control and aim to build *confidence* (Siegrist et al., 2003) in the system's ability to function in the future. Arguably, the food system is managed through a combination of liability and accountability, operating through systems of codes of conduct, standards and certification schemes (Bingen and Lawrence, 2006) by which different agents are held to account.

Legitimacy is a construct closely linked to responsibility as both deal with the issue of authority. Scharpf (1998) distinguished between input legitimacy based on adherence to agreed processes of authority, and output legitimacy, which is derived from the achievement of an agreed set of outcomes.

Global food systems are characterized by the reduced authority of a single institution—the state—and therefore legitimacy is gleaned from the balancing of various actors' responsibilities. The dominance of corporate actors in the modern food system is based on output-based legitimacy, judged through the system's ability to effectively support the commonly agreed goals (Partzsch, 2011). Timotijevic et al.'s (2019) study of 300 EU stakeholders' assessments of food R&I demonstrated that inadequate consideration for input legitimacy is of a major concern for civil society and public sector actors. For the corporate sector, in contrast, governance is considered legitimate if it achieves the system's aims regardless of the means by which it does so.

Different dimensions of responsibility have different implications for how power is shared, exercised and controlled within a system of governance. Accountability can easily lead to hierarchical organization of relationships because it is premised on the fair and mechanistic process of accounting of decisions made. It can often lead to differentiation of power based on the ability to exercise controls over the accounting process. For instance, actors will have a varying ability to collect indicators and evidence to account for actions. However, the desired transformation within the global food system can only be achieved through sharing of power between a broader set of actors, through "democratization" of governance (Lawrence and Friel, 2019), which in turn emphasizes the relational aspects of responsibility that are underplayed when only looking at accountability (Vetterlein, 2018). In other words, it opens up the space to deliberate about what responsibility means and how best to enact it. The dimensions of care and responsiveness allow for participatory decision-making and sharing of power to both identify and construct possible solutions to global food system challenges (Lawrence and Friel, 2019).

Pallizzoni's nuanced extrapolation of different types of responsibility has been applied to the environmental domain (e.g., forestry management—Löfmarck et al., 2017; biomass refinery Sonck et al., 2020), where it has been shown to have analytical relevance in exploring the governance processes, but it is yet to be examined in relation to the food system. Within this paper we report on a study which explores the conceptualizations of responsibility within the context of food research and innovation (R&I). We are guided by Peillizzoni's understanding that responsibility cannot be reduced to a single notion (e.g., of accountability) and explore stakeholders' understandings of responsibility as they play out in the context of food R&I.

R&I are key to the current global and national efforts to achieve the targets in the Sustainable Development Goals (SDGs) (UN SDGs, 2015) 2030 Agenda such as SDG2 (address hunger), SDG3 (health and wellbeing for all), SDG 12 (sustainable consumption and production) and SDG17 (partnerships to achieve the goals). Simultaneously, R&I raises diverse and unprecedented ethical, legal and social challenges, which call for greater clarity about responsibility within R&I networks. R&I within the food system is largely characterized as an interaction between industry and academia, aligning innovation

with the dynamic of an unconstrained market (Khan et al., 2016) and raising issues about responsibility within such strategic public-private networks. Understanding how diverse stakeholders in the food R&I conceptualize responsibility is vital because it shapes the way problems are identified, goals are set, and solutions are put in place. Burget et al. (2017) call for more empirically-based studies to better develop understanding of the concept and what it means for those called upon to apply it in real world R&I. This is especially noticeable in the area of research on the challenges currently surrounding the food system, whereby responsibility raises diverse and unprecedented issues of animal welfare, public health, sustainability and social justice. Our study uses three cutting-edge R&I domains—hybrid potato breeding, cultured meat and weight acceptance programme as examples to draw upon common conceptual threads that reveal the dimensions of responsibility for the various food system actors or stakeholders such as public sector, private sector, R&I institutions and civil society. The three domains selected provide a broad scope of ethical and governance challenges that enable rich discussions about responsibility.

METHODOLOGY

We identified the domains of R&I from which to draw our stakeholders through a systematic process of search and selection. Our aim was to identify stakeholders clustered around R&I projects which gave rise to dilemmas about responsibility in terms of who the innovation is for, what kind of relationships it espouses between different actors in the society, and how it is likely to influence the future food systems. The selection was carried out through key informants' consultations and extensive searches of EU CORDIS (Community Research and Development), which led to the creation of a long list of projects based on the following inclusion criteria: projects were conceived between 2011 and 2016 (the period that the RRI concept entered the policy discourse), were at least partially publicly funded, and recognized the need for societal engagement. We then created the short list of six projects which had a strong innovation element; were of diverse provenance (geographic location) and were innovations with different ethical challenges. The final selection of three projects was based on achieving maximum diversity of challenges relevant to the food system (covering agriculture, food technology, and public health nutrition domains), from which to draw our interviews. The three projects identified included: an international project on hybrid potato breeding; an international project relevant to cultured meat; and a national weight-acceptance obesity intervention. By selecting these projects, the study was contextualized within three key challenges: (1) the need to increase the crop yields to feed the growing population; (2) the need to develop an ethical and sustainable protein production system; and (3) the need to address the global obesity crisis in the developed world. Below we summarize the three projects with reference to the ethical and societal dilemmas that they give rise to.

Empirical Application: the Examples of Research and Innovation

Hybrid Potato Breeding (HPB) Project

The HPB project was set up to protect potatoes against diseases by developing hybrid seeds which accelerate breeding and allow rapid modification. Hybrid breeding is an innovative technology to improve crops by crossing the crops that demonstrate favorable traits in order to create a completely new line (Lindhout et al., 2011); the selected project is developing methods of breeding potatoes that will allow them to be reproduced more quickly using true hybrid seeds (<https://www.solyntha.com/about-solyntha/>, accessed 12/01/21). This could increase the speed at which potatoes can be modified through breeding, but also help their transportation as the seeds occupy a fraction of the weight and volume of potato tubers. However, growing potatoes from seed poses ethical and legal challenges, including: (a) How ethical is patenting a new strain of seed as a living material for commercialization purpose? (b) Can plant breed patents be used to restrict access to agricultural innovations, creating an imbalance in power between large agri-tech companies and local farmers, and between the developed global North and the developing global South? (c) How to balance economic interests of innovators with the interests of local farmers and create global legal regimes that cater for different interests?

Cultured Meat (CM) Project

The selected CM research project mapped out the challenges faced by CM at the levels of policy-making, funding and industry right down to that of the individual consumer to address a question—should society invest in the development of cultured meat? There is a broad consensus that conventional production of meat based on intensive animal husbandry is difficult to sustain due to its environmental, ethical and human health impacts (Stephens et al., 2018). A technological innovation in meat production is being developed as a replacement for livestock meat: the growing field of *in-vitro* meat (IVM—now more commonly referred to as “cultured meat”) represents a new innovation pathway called “cellular agriculture” (Post, 2012). It involves using stem cell research to grow animal muscle tissue in a lab that can then be layered to produce food for human consumption. Despite its promise, cultured meat has been linked with a number of challenges. New techniques capable of developing CM more quickly and on a much larger scale would need to be developed for these benefits to be realized (Hocquette, 2016). Its adoption will largely depend on whether it leads to new social and economic inequalities in terms of who is able to produce and who will be able to consume it (Stephens et al., 2018). The main concern is that introduction of CM into our food system would inevitably shift the balance of power into the hands of global agribusiness, and may potentially exacerbate the global North/South divide. The current regulatory and institutional context are woefully inadequate, and safety of the CM products will need to be assessed not only in terms of processing and food safety, but also for their long-term effects upon human genetic, metabolic,

reproductive and physiological functioning (Stephens et al., 2018).

Weight Acceptance (WA) Project

The rapid rise in obesity is thought to be caused by the current global food system which creates an “obesogenic environment” (Swinburn et al., 1999), the physical, economic, social and cultural environments that encourage positive energy balance in their populations. However, current public health policies ultimately place responsibility to avert the rapid progression of the obesity epidemic upon an individual, and by singling out weight as a determinant of ill health, prioritize weight management and reduction as the main route to achieving public health. This approach has been criticized for not recognizing the broader, systemic causes of obesity, leading to instances of discriminatory healthcare practices (such as withdrawal of some treatments—e.g., knee replacement, fertility treatment—due to weight), raising complex ethical dilemmas. This final research project challenges the dominant weight-based paradigm of dealing with the obesity crises. It pioneered social innovation developed and implemented to tackle obesity through the “weight inclusive” approach that promotes the acceptance of bodies of all sizes, whilst simultaneously drawing attention to broader determinants of health.

Participants

Participants were purposefully selected to represent a range of stakeholder perspectives on the innovation and occupying diverse roles within the domain-specific R&I process—some were directly linked to the project, as either directly funding or conducting research (e.g., scientists; research funders); whilst others were sitting outside the immediate process of R&I in the respective domains (e.g., civil society organizations, policy actors). Representing all stakeholder groups equally was logistically impossible. Industry stakeholders proved harder to recruit as they were fewer in number to begin with, tended to be less involved in the research process than the researchers and have been less invested in having a specific agenda heard than the third sector organizations. The Weight Acceptance project was run entirely in the context of the UK health services, drew on the UK National Health Service (NHS) for support that might otherwise have come from industry or the private sector and therefore had no meaningful relationship to industry, and thus no industry stakeholders. However, the fact that interviews were unevenly distributed across stakeholder groups was not considered a major obstacle as this paper does not seek to generalize findings or speak for entire stakeholder groups or research domains. Moreover, as a qualitative analysis, generalization is not the objective. Instead, it aims to explore the thematic categories cited as important by these particular examples of stakeholders within different groups. Every effort was made, however, to engage the stakeholders who were either existing inside the R&I process, or who were sitting outside it though had a stake in the innovation domain. The participants are detailed in **Table 1** below.

Due to the small number of interviewees and their often-unique expertise, roles and prominent standing in three relatively

TABLE 1 | Participants by case study.

Stakeholder category	Cultured meat	Hybrid potato breeding	Weight acceptance	Total
Third/Fourth sector organization ^a	2	1	2	5
Policy maker	0	1	12	13
Research Funder	0	0	2	2
Researcher	4	4	1	9
Industry	0	3	0	3
Total	6	9	17	32

^aThird Sector organization (TSOs) are citizens' interest groups, such as civil society organizations and labor unions, as well as religious organizations and informal networks of citizens, often motivated by moral, ethical and ideological concerns.

narrow domains, only the demographic information deemed necessary to address the research questions was collected, in order to maintain the confidentiality of interviewees. Moreover, because actors spoke as representatives of their organizations rather than as individuals, gathering personal information was deemed irrelevant. In addition, delineating participants by country was not found to be useful as many spoke for international projects, were based in countries other than their countries of origin and very often the most meaningful geographic unit of analysis was that of the EU rather than that of individual nations. The exception to this was the Weight Acceptance project, which took place entirely in the UK and involved only UK stakeholders.

Procedure and the Interview Schedule

Semi-structured interviews were chosen to allow flexibility in following up on participant-relevant issues. The broadest aim of the research was to talk to the actors within the R&I system about how they understood responsible R&I and what “responsibility” meant to them. Participants were firstly asked to describe the project and explain their roles within it, after which two main issues were explored: how responsibility in R&I was conceived in general, and in the context of the project; and the process of societal engagement within the project. The interview schedule also prompted the interviewees about how the concept of responsibility related to the notions of trust, impact, openness, and engagement with society. The interviewees were not asked to apportion blame or indicate their understanding of the causal attributions of responsibility within the context of their respective R&I domain, to avoid biasing the discussion. Interviews were transcribed from audio-recordings. Informed consent was obtained, and the interviews were conducted in person or via telephone.

The University of Surrey Ethics Committee granted this project a favorable ethical opinion on 19th July 2016 (UEC/2016/031/FHMS). The interviews were carried out during the period of Nov 2016-March 2017.

Analyzing Data

Thematic analysis (Braun and Clarke, 2006) was conducted within, and then across the three cases. Thematic analysis was chosen as it allows the accounts of different types of stakeholders to be examined without privileging any particular perspective or framework. It does this by using the data itself as the basis for generating and refining categories on an ongoing basis. This both facilitates a rigorous methodological approach and allows the flexibility to validly reflect the arguments of participants whilst maintaining a reflexive awareness of researchers' own biases and preconceptions. Our epistemological orientation was that of social constructivism (Burr, 1995), which posits that meaning and experiences are created through social interactions—the focus was not on individual motivations, but on the meanings and (lay) theories as emergent properties of the socio-cultural contexts of those group interactions. Our approach to thematic analysis was a combination of inductive and deductive coding—whilst we engaged in a close reading of the transcripts, we were nevertheless guided by the existing frameworks of responsibility. The initial coding structure was developed by two researchers, following which, the team discussed and developed the themes with an aim of identifying dimensions of responsibility.

RESULTS

Differences in how interviewees conceptualized responsibility in R&I were not clearly aligned with a single R&I domain or any groups of stakeholders. While participants offered a variety of opinions about responsibility, these were more likely to vary between individuals than by stakeholder group or indeed the R&I domain. It was even common for the same participant to characterize responsibility in different ways when discussing different aspects of R&I. Within the analysis we explicitly attribute quotes to different projects, which allows us to draw attention to any differences in conceptualization of responsibility that may be associated with the specific domain in question.

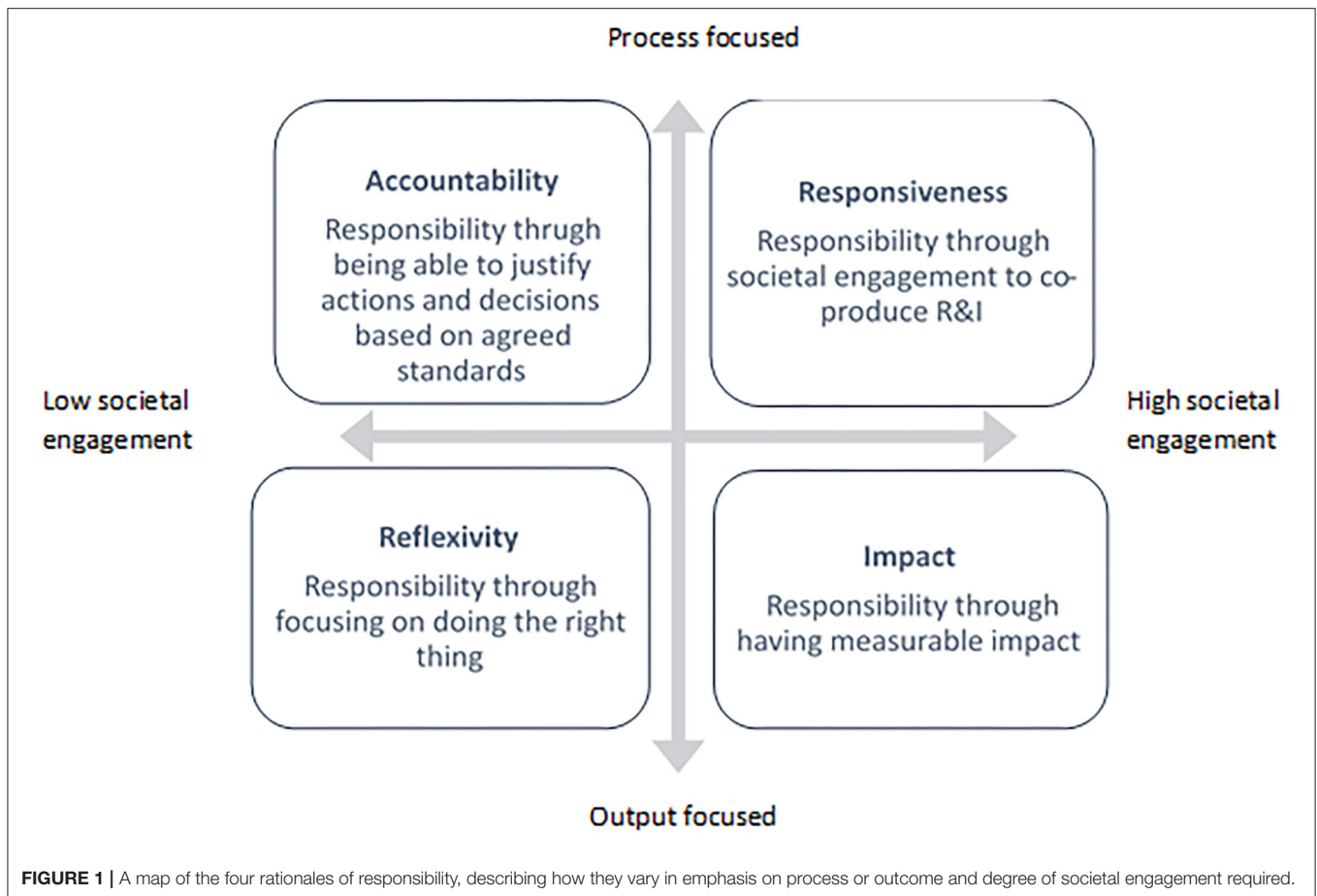
Four overlapping rationales of responsibility were identified across all three case studies: (1) responsibility as accountability; (2) responsibility as impact; (3) responsibility as reflexivity; and (4) responsibility as responsiveness.

These four varied most meaningfully by the degree to which they depicted the assessment of responsibility as focusing on the process of research or its outputs and the extent to which doing so was depicted as requiring societal engagement. This can be described on a 2 × 2 matrix, as illustrated in **Figure 1** below.

The following sections describe each of these rationales of responsibility in R&I in turn, focusing on how it might be achieved within the current food R&I governance.

Accountability

Under this rationale, responsibility is assessed in terms of individual actors working within the research process as agents accountable to their principal for servicing specified goals in compliance with ethical and institutional guidelines. Under the accountability rationale research goals are chiefly decided upon by those holding the purse strings.



Participants recognized that the modern principal-agent relationship (which applies a customer-contractor relationship to science governance, Cooksey, 2006), was a significant divergence from the cognitive authority model of science that is based on assumptions of expertise, impartiality, and the need to protect science from the external influences, such as governmental pressures to make science “useful” (“The Haldane Principle,” Haldane, 1918). It re-cast responsibility as no longer simply deriving from the cognitive authority of scientists to speak truth to power, but instead as a narrower, relational responsibility to the relevant authority (Guston, 1996).

“I can imagine that a researcher in the past had more freedom to operate and to investigate what he thought was best, now there are limitations in what can be done due to money availability.”
(Researcher, HPB)

The above extract is typical of interviewees in suggesting researchers now bear limited responsibility in steering the direction of their research rather than merely for fulfilling their allotted role in its process.

Participants from each of the three domains (CM, HBP, and WA) identified two fundamental shortcomings of this narrow conceptualization of responsibility through the lens of accountability: its failure to acknowledge the uncertainty

inherent to the research process in how it is governed, and its implication for trust.

Some participants argued that the accountability model of responsibility creates pressure to explain away uncertainties and ambiguities inherent in the science process via external pressure to comply with the procedures that often do not permit deviation from the outcomes and processes agreed upon with the principal *apriori*. One interviewee argued that principals’ desire for clear and unambiguous answers risks misrepresenting a process that was, in truth, often messy and unpredictable.

“I would like to see modes of accounting that allow ambiguity and uncertainty to be visible in the account. I think there’s a general sense that, you know, acknowledging uncertainty is not done as widely as I would like to see...” (Researcher, CM)

The most common criticism of this rationality was the fundamental imbalance of power and the trust vacuum that it creates. In the following extract, a CM researcher describes a “principal’s” (funder’s) freedom to entirely discount researchers’ ability to judge what constitutes a responsible research process as symptomatic of a deeper distrust.

“I think one of the things that should...that should be done is make it sort of less bureaucratic—lose a lot of the red tape because that’s basically a sign of distrust in how people are doing

their work. It has gone completely awry and it's sending the wrong message. It's sending the message, you know, "We don't trust you when we give you money, you need to tell us exactly what you're doing, how you're doing it, when you're doing it, and that turns into a very bureaucratic, automatic system that really doesn't support creativity." (Researcher, CM)

When responsibility is primarily conceptualized in terms of accountability, it is perceived to have a detrimental effect on trust between key actors within publicly funded science. Emphasis upon accountability introduces external criteria for "responsibility," based on (often backward-looking) assessments of compliance with due processes, rather than enabling a conversation about what constitutes responsibility within the framework of meeting the principal's needs. The deeper consequence of conceptualizing responsibility as accountability is that it is only relevant to those stakeholders who are directly involved in R&I process, precluding the wider interested actors such as civil society organizations.

Impact

Assessing responsibility as impact required being able to demonstrate positive real-world research outcomes:

"'Responsible' is R&I having a positive societal impact, and there, of course, you introduce a value, positive, which can be debated in all kind of ways. It's very subjective. So, we started with, when I think back, with that concept, how can we make Intellectual Property (IP) in plant breeding having a positive impact on farmers, and, at the same time, avoiding that it will ever have a negative impact on some kinds of farmers. So that is on what you want to achieve with your research in terms of output." (Researcher, HPB)

Such assessments typically emphasized measurable short-term economic benefits assumed to generate longer-term prosperity and ultimately to help society meet broader challenges such as sustainability and food security. The relationship of innovation and economic prosperity was spelled out by a scientist on the HPB project.

"It's economic, and we usually don't consider that as a value, but of course it is a value, it's something to be valued. It provides jobs, and it brings money to the country, and it brings good potatoes to the world! And then, you know, we try to incorporate other values than just that, and that's part of our challenge." (Researcher, HPB)

There were several concerns raised by different stakeholders associated with this rationale of responsibility, which included: emphasis on commercialization of innovation; short-termism; and imbalance of power in deciding innovation pathway.

Conceptualization of responsibility as an ability to achieve impact positions it outside the process of research and the purview of scientists, which raises questions of where control over the R&I actually resides. A policy maker involved in the HPB project was one of several participants who suggested this often amounts to allowing research directions to be primarily determined by "commercial players."

"I think the whole debate about the public good is put in the hands of the markets, and of course the commercial players, and so I think this is a sort of very fierce, uphill struggle that you have, you will have with RRI [responsible research and innovation], because this is also the sort of wall you will come against in thinking about RRI." (Policy maker, HPB)

This positions "the markets" as exerting considerable control over which outputs are judged responsible and therefore on what future work is commissioned, but what of the influence of government funding bodies whose remit includes ensuring that research impacts serve the needs of wider society? The following account from the same policy maker suggests that while governments do play a role in allocating funds under the Impact rationale, it is often private sector organizations who lead the way:

"You have the Ministry that is stimulating innovation but, in a way, that basically, positions the commercial parties as the drivers of innovation. And doesn't see a role for itself in really shaping these innovation trajectories. So in that sense I think that responsible R&I is a concept that will not really be seen by our parliamentarians as a very important issue." (Policy maker, HPB)

The tendency for governments to let industry have the first say in setting "innovation trajectories" is here explicitly linked to the imperative to achieve economic growth through innovation, and reducing the role of science primarily to the economic value:

"As soon as the industry shows interest, the government is willing to match that kind of money, to enhance research anyway. They see the benefit of the working relationship between researchers and the companies." (Researcher, HPB)

It is suggested that having to take on faith this hope that economically motivated research will also contribute to a better society is problematic. If, as the following extract suggests, it is only the short-term economic impacts that can be validly measured in the limited timeframe principals are interested in, then funding research largely on the basis of longer-term societal benefits can no longer be considered responsible. At this point the logic of the Impact rationale becomes as self-perpetuating as the power of those who profit from it.

"Perhaps it's very naïve of me, but I hope that then the, yeah, ultimate goal is for societal benefits, as opposed to monetary ones. I think it's really hard to ever judge social or societal impacts of any single project. Ask me in 5 years or 10 years and I might be able to answer your question more thoughtfully. So, I think that the funder's need to assess and justify impact doesn't fit right with how we can actually truthfully measure impact [laughing]." (CSO stakeholder, CM)

Interviewees across all three cases manifestly differentiated between economic and societal impact decoupling the former from its positive connotations. The same CSO stakeholder emphasized the need to ensure that responsibility is no longer conceptualized solely in terms of economic impact, as a way of democratizing the process of R&I.

“I think research, recently, seems to have become very tied to industry, and it has to have economic outcomes at some point, and so, hopefully, responsible R&I [laughing] is saying, well, it doesn't have to have an economic output, as long as it has a societal benefit.” (CSO stakeholder, CM)

The danger of creating self-perpetuating structures of power intolerant of dissenting views was particularly strongly argued by participants from the WA domain. The project's founder argued that her funding was jeopardized precisely because it challenged dominant assumptions about food.

“The drive for a monolithic ideology, which is what I discovered [name of other health programme] was. Perhaps I did know it on some level. It wasn't what I was working toward, but being silenced absolutely drove that home to me, and that...that's fascism.” (Researcher, WA)

The Impact rationale of responsibility, unlike the Accountability, does include a role for members of the public, though not as citizens who might help align research trajectories to societal needs but as consumers or potential innovation users.

“... [large company] is too much short-term in their way of thinking, so if they want to do research, they want their money back in 2 years. No, that's not going to work in this kind of research. And yeah, they listen very closely to what their consumers want and they simply deliver that.” (Researcher, HPB)

Engagement therefore takes place as part of design process, follows set lines and is targeted downstream at user/consumer groups whose uptake is required, as distinct from the more participatory, upstream approaches to engagement:

“I strongly believe that research is a two-way street. I mean, you have to communicate with the people who are going to use your knowledge because, for one thing, you want to know the questions they have and that makes what I'm saying more relevant, if I take their response into account.” (Researcher, HPB)

Engagement within this rationale focused on delivering an innovation better adapted to its intended market. However, participants across case studies expressed the desire to embrace more flexible definitions of socially responsible impacts that challenged the “hegemonic” assumptions about what constitutes impact through careful reflection and by opening up engagement to those sitting outside the process of innovation.

Reflexivity

The participants argued that they had a duty to be reflexive about their own research processes and anticipate all potential outcomes for society. A researcher on the HPB project described this in terms of a collective responsibility amongst scientists, one born of the culture of science but not bound by its rigid organizational structures.

“You have the responsibility to think about the impact of your research outside of your domain of research. I think it's also very

much the structure of science, which is organized so that it does not promote this kind of thinking, so yeah, it's not the scientists' personal responsibility, but it is our responsibility as science, as a science system or as scientists together, to think about society.” (Researcher, HPB)

The interviewee's insistence on collective rather than personal responsibility also distances it from the belief that responsibility requires the ability to trace negative consequences back to individual actors in the research process and hold them accountable. Instead, the community of scientists and the values it embodies become the crucible through which responsible research is forged.

Crucially, while the Accountability and Impact rationales focused primarily on retrospective assessments of responsibility, the Reflexivity rationale locates responsibility in anticipating unforeseen challenges and absorbing future shocks. In the following extract it is argued that responsibility means being aware of all potential future consequences of introducing a powerful new technology, not just whether it will achieve the intended goal:

“In the context of this innovation, you can think about the development of technology in a purely instrumental way. So you have a particular goal set for what you would like to achieve, and the technology is a means to realize that goal. And in my view, responsibility means that you are open for the fact, that I would say, the fact that technology is always more than just a means to an end. It will also, it will always interfere in unexpected ways in all kinds of processes. And then for me, responsibility in that context would mean that you really take care in the sense that you see yourself as someone who should be part of the conversation about these different effects, and that might result from the development of a particular technology.” (Researcher, HPB)

Responsibility here takes an important step beyond the scope of the innovation's intended impacts to examine its unintended consequences. What is implied to be irresponsible is treating a new technology as nothing more than a value-free instrument for achieving a specified goal. For a CSO stakeholder on the WA project this extended to considering the risk of exacerbating existing social and health inequalities.

“The responsible bit suggests to me that you need to be very clear about the impact of what is going to be said because so much of our research has actually skewed things in a way that a population, usually the most deprived in a community, have been further disadvantaged by that. So, I guess that's what I mean about the social justice bit.” (Researcher, WA)

This frames the danger of research widening existing social divisions as not just a possibility to be guarded against, but a common occurrence. Participants on the WA project were especially likely to raise this issue, of the three case studies they after all had the closest connection to the people affected by their innovation. Indeed, it was rare for participants on this project to discuss social injustice without addressing the related question

of—to what extent the privilege of working within the innovation process made them responsible for challenging this injustice.

“I want it to shift our way of being in the world, and that means our relationship with language and our relationship with power; it doesn’t mean deskilling people, doesn’t mean deskilling myself, but it means recognizing that I have a certain cache of social capital and that, if I’m serious about social change, it has to be radical.” (Researcher, WA)

This frames responsibility as a moral imperative to question existing power relations, including one’s own role, to reflect on the parts played by language, symbols and social hierarchies in deciding how innovations and research are promulgated. Equally, though, it is also a call to action. In the following example, a researcher on the HPB project discusses a researcher’s obligation to act in a scenario in which an innovation endangers the livelihood of smallholders by rendering their potato growing methods obsolete.

“The company that’s involved in this programme, well, they have a very clear technological solution for [the problem] but that technological solution is going to change the landscape of potato production in the [country], very much so, and probably in the world, ... so yeah, you can’t simply just start and say “Okay, this is the new technology—you better adopt it because otherwise you won’t be in business anymore.” You have to really change the whole... the whole thing.” (Researcher, HPB)

This process of being reflexive about underpinning assumptions, the way language frames research questions and shapes research processes, was considered an important way of enacting responsibility.

“It wasn’t only about values, it was also about the framing of, for example, what is a child or what is a neuro-scientific researcher, what should the teacher be doing, and then you see that there’s all these things that are actually not really mentioned, these assumptions that are... that it’s good to bring them into the open, just to create some sort of... understanding, and also reflexivity about your own assumptions.” (Researcher, WA)

In contrast to the Accountability rationale, researchers are not merely responsible for the conduct of the work itself. Rather, in addition to following ethical and professional guidelines, they must continually strive to connect the underpinning assumptions and values they bring to the project with its potential societal impacts. In the following extract, an HPB researcher frames the ongoing nature of this attentiveness as a way of acknowledging the limits of one’s ability to realistically anticipate all possible outcomes.

“It’s a way of better dealing with the uncertain future, but the future is still uncertain, you know... and I think there’s just in that sense limitations on what kind of values you can take into account, because you know, you basically don’t know all the values that may pop up, you have to keep being attentive...it is a continuous process. So what we’re doing is not, you know, this is RRI and then you tick the box.” (Researcher, HPB)

In addition to being a way of pre-empting negative outcomes the participant positions continually “being attentive” as a way of being transparent about the fact that not all negative outcomes can be predicted, nor all damages prevented. Responsibility through reflexivity distances researchers from the need to account for all steps in their day-to-day research. As discussed in the earlier sections on Accountability and Impact, such reductionist conceptualizations of responsibility preclude engagement with the uncertainties and the unknowns in the process of R&I and has a contradictory effect of arguably reducing anticipatory reflexivity to just those issues that can easily be measured or accounted for. Reflexivity rationality instead reframes responsibility as a duty to anticipate and seek to communicate the future challenges that R&I are addressing and the ultimate need to articulate a framework for collective leadership and responsibility in R&I, as argued for by a researcher from the CM project:

“But this is a huge challenge, isn’t it? I mean, we’re talking about thin, tiny, little attempts at a task that is formidable. We’re talking about a change in the culture of R&I. We’re talking about changing the social contract of science and society.” (Researcher, CM)

Responsibility as reflexivity calls for a form of collective leadership based on the moral imperative to achieve public good. The extract below is an emotional plea to move away from the demand-pull understanding of innovation that gave rise to Accountability and Impact rationales of responsibility toward the responsibility based on ethical deliberations and value judgments that go beyond the market dynamics.

“What struck me most, was that also people from the sector said ‘this is not what we are going to do, because the consumers don’t want it’. And I really was a bit angry about it, I must say, because then my question would be, and I posed this question to them, ‘if you, if you think there are very good reasons to take up this kind of potato, er... why could you, why couldn’t you tell this to the consumer?’ And promote this potato as something that really is something that might interest you as a consumer, because it is a response to, to very important problem in potato production. So, it, is just using the consumer as a sort of shield ...” (Researcher, HPB)

Participants from all case studies were more likely to describe reflexive responsibility being realized in interdisciplinary collaboration and consultations within the research community than by speaking to members of the public.

“Responsible research does not necessarily have to fit in a kind of straightjacket of participation, not necessarily. I think it is almost always interdisciplinary though because you want to include different social sciences in your natural science research, in order to properly think about societal impact. It does not necessarily have to involve societal partners.” (CSO stakeholder, HPB)

The point suggested by the straightjacket analogy, suggests that responsibility through reflexivity involves an opening up of

definitions and participation amongst a community of allied experts rather than conforming to a strict externally imposed formula of societal engagement. This frames responsible R&I as depending less on societal engagement and inclusivity and more on a collective commitment to honest reflexivity about research outcomes, including unintended outcomes and those affecting disadvantaged groups in society. Nonetheless its focus on introspection within the research community lays it open to charges of lacking transparency, inclusivity and potentially saying much but doing little to address the role of power relations in deciding the future of science.

Responsiveness

The final rationale envisages responsibility as shared decision-making through active engagement with societal actors. It frames co-production as the essence of responsible R&I, distancing itself from the Impact rationale's understanding of engagement as solely an instrument for eliciting needs in order to inform, rather than influence, decisions. Instead, co-production implies openness to diverse values, skills and forms of knowledge, empowering each stakeholder to contribute on the basis of their uniqueness. This is a process-oriented (performative) notion of responsibility as opposed to output-oriented (substantive), one which brings democratic processes to science governance. Like other rationales, however, this one is also problematized by respondents, who expressed two main concerns: regression to the mean, or the rule of the average intrinsic to the practice of societal engagement; and the practical difficulty of achieving consensus among disparate positions. Both of these problems were ultimately considered to be barriers to R&I. Sharing power in a balanced way across networks of collaborators was crucial to this rationale of responsibility.

"I see RRI as part of an ongoing socio-technical discursive, dialogue, set of practices, constellation of actors and interests, that are trying to frame appropriate relationships between various forms of innovation, some notion of democratic representability, you know, political accountability, and, notions of expertise, which again are flexible." (Researcher, CM)

The focus on networks of evolving relationships echoes Stahl's claim that "Responsibility can be understood as a social construct that establishes relationships between a set of different entities." (Stahl et al., 2013, p. 200). Crucially, this approach combines the need for some form of accountability as science is a largely publicly funded endeavor, with democratic responsibility, because science ultimately impacts society.

"Researchers have a responsibility toward society because their research will be in society if it needs to impact society, but you are doing research within society and you're also being paid by society, and yeah, I think responsibility is very much paired with an idea of the democratic science system." (Researcher, HPB)

The concept of "democratized system of science" is a move away from the binary understanding of responsibility through the lens of expertise—whereby responsibility is narrowly centered on the networks of experts and their principals. Instead, Responsiveness is manifested in engagement with broadest sections of society,

as an opportunity to question existing power imbalances and dissolve the distinction between the notional expert and the member of the public:

"It's...just a neoliberal...it's completely neoliberal. Even sustainability, you know, food sustainability, it's 'How can we help them?', so there's a 'them and us', you know, 'How can we help them to eat well?' not 'How can we change the power relations?' And also 'How can we use our work, how can we use food work to shift power relations?' and that's what I want from [WA project name], to have different conversations." (Researcher, WA)

The distinction between a well-intentioned but paternalistic and implicitly elitist approach to engagement and one that enables "different conversations" between equals came through most clearly from participants from the WA study with the closest relationship to the wider public.

Nonetheless, even in the less public-facing HPB project, another researcher went so far as to frame this new, more democratic relationship between innovation and the public as a radical inversion of traditional roles.

"... RRI is really an attempt, quite a radical attempt to change this... by putting up-front the question of the needs for innovation, the sort of societal challenges that should direct innovation, and the interesting thing is that then you could say that the societal stakeholders then become the enactors, and the technologists become critical responders in a way, because they have to think about whether, indeed, their science is able to respond to that question. And that, of course, has to be a real conversation, because both parties... it's mutual learning." (Researcher, HPB)

What initially seems an inversion of roles between experts and society here is eventually transformed into a leveling in which expertise and power, and therefore responsibility, become properties of all actors in the network. All are now responsible for their own contribution to the process and, collectively, for the process itself. This is reinforced by the use of the same description of engagement as a "conversation" in the excerpt above, suggesting some level of equity between different kinds of stakeholders and, by extension, the different types of expertise they bring to the table.

Casting members of the public not as outsiders to the research process but as "societal stakeholders" within it, recalls earlier descriptions of research as a "two-way street" under the Impact rationale but goes far beyond that model in terms of the purposes of engagement. Rather than simply using public input to make the products of innovation more likely to succeed, the above account affords societal stakeholders a key role far earlier in the research process. Participants did not necessarily portray early societal engagement an impediment to fulfilling the goals of funders, but an essential part of innovation process.

"I recognize the importance of people like me, but also people doing lots of other things that are different to what I'm doing, being actively involved in the debates that shape

modes of innovation and being involved in them early on.”
(Researcher, CM)

The following account framed engagement more as a way of contextualizing those goals within the needs of society and gaining a better understanding of the network of relationships currently making up the specific sector involved.

“We started with a study of what you could call the potatoes sector, which is to some extent a value chain, but it’s in many respects a value chain which has a network character. And studying this, on the one hand, the purpose of making ourselves familiar with everything that relates to the potato, and all the different parties involved. But, we also see it as a very important starting point for thinking about future scenarios, because every scenario you might think of, of course, has to start in the present and will be shaped in different ways by the established relationships and goals and values that are part of this network.”
(Researcher, HPB)

Responsibility for R&I then becomes a collective responsibility distributed across the network of various societal actors as an emergent property of that network that could not be generated by any one actor or set of stakeholders working alone. This shared responsibility implies freedom from personal accountability but also a surrendering of individual control. This can be a problem for those who associate innovation with accountability of actions linked to the specific actors within the network. It also can challenge the demand-pull concept of innovation which relies on the motivation to innovate in order to achieve and exploit the Intellectual Property rights and would require being able to preserve one’s unique vision rather than achieving consensus and compromise:

“Science, well, especially the multi-reviewer type of things, tend to be very democratic and sort of regressing to an average, so you have to find the common denominator between the different reviewers, and that’s—for radical innovations—that’s tough.”
(Researcher, CM)

In short, societal engagement is a manifestation of Responsive responsibility because it creates conditions for consensual and collective decisions within the network. It is a process-oriented responsibility, one which is open to criticism of ignoring the pragmatic difficulties of making any powerful innovation work in practice.

DISCUSSION

Our research examined the discourses of stakeholders currently engaged with food R&I. Through thematic analysis we identified coherent accounts about what constitutes responsibility and mapped these to four distinctive rationales of responsibility. Each rationale is characterized by a specific R&I governance arrangement which emphasizes either the process of R&I or its outcomes, implies different roles for societal engagement, and promotes alternative methods for assessing responsibility. **Table 2** summarizes the classification and the associated policy implications. These to a large extent echo Pellizzoni’s typology

of responsibility. To some extent they also reflect the typology created by Glerup and Horst (2014), who, based on their review of 263 published articles (albeit not within food R&I), have highlighted process vs. outcome-focused assessment of responsibility as an important dimension in their typology.

Our results suggest that being responsible means not just implementing one rationale of responsibility but balancing many—a kind of “meta-responsibility” (Stahl et al., 2013) that indicates potentially competing models of food R&I governance. The diverse rationales discussed by the participants co-exist across the three cases. Within each, Accountability and Impact are recognized as current drivers of food R&I governance. The participants link this to the concentration of investment in research areas most amenable to quantifiable cost-benefit assessments, and in turn, R&I being increasingly held responsible for economic growth, research output exploitation and furthering of commercial interests. The participants recognized that such reductive understandings of responsibility are particularly problematic within the R&I relevant to building a socially fair and sustainable food system, as it needs to recognize uncertainties, co-dependencies and values that go beyond the quantifiable metrics. Both Reflexivity and Responsiveness rationales articulate these uncertainties and inter-dependencies, locating responsibility not within a single individual but either within the collective conscience of innovators and researchers or within the wider network of food actors. Both rationales seem to endorse “technology of humility” (Jasanoff, 2016): within Reflexivity rationale, it is explicitly linked to the ethical deliberation of those directly involved in R&I; within Responsiveness rationale, this is done through societal engagement with those sitting outside the research community. The participants unequivocally recognized the need for cultural embeddedness of ethical and social deliberation within R&I for a sustainable food system that recognizes responsibility as an emergent property of the food R&I network. The process of R&I and the attendant responsibilities will cease to rest with Foucault’s “responsibilized” individual stakeholders (Lemke, 2015), but with the network of relationships connecting them, echoing May (1992) and Young’s (2006) Social Connection Model of responsibility. Young argued that structural injustice can emerge as a consequence of actions of many individuals and institutions within a network, each acting in pursuit of their particular goals and interests within the norms of their institutions. Even when the actions of each individual are clearly compliant with these rules and norms, the system itself might nonetheless generate unintended outcomes, which cannot be traced back to any individual. Our study suggests that the challenges of food R&I for a sustainable food system require a greater recognition of different rationales of responsibility, echoing these arguments. This does not mean removing accountability as a backward-looking rationale for adjudging responsibility, but asks of all actors within the network to anticipate how accountability as one of key rationales of responsibility frames the problem and the possible solutions, inadvertently obstructing transformation toward sustainable food system. The forward-looking assessments of responsibility (Responsiveness and Reflexivity) shift the focus toward greater

TABLE 2 | Rationales of responsibility in the context of food R&I.

Rationales of responsibility	Responsible to whom	Governance of R&I	Relationship between society and R&I	Methods for assessing responsibility
Accountability	Describes researchers' contractual obligation to those who commission, fund and evaluate their work as reflected in principle-agent R&I governance.	<i>Process-oriented R&I governance</i> Focuses on processes of accounting based on pre-agreed measures.	Social contract between society and science managed through a nexus of institutions established to ensure transparency in the governance of R&I, in keeping with the social contract. No explicit requirement for the engagement of society – different institutions (e.g., retailers, funding agencies) act as the guardians of societal interests.	<i>Backward-looking evaluations</i> of responsibility, assumes an ability to identify <i>causal factors</i> for any shortfalls in the process of R&I. Approximates a legal concept of responsibility as liability for consequences resulting directly from research process and traceable to individual actors in the system.
Impact	Responsibility to those who stand to benefit from R&I—users and consumers.	<i>Output-oriented R&I governance</i> Links R&I to explicit measures of impact as reflected in the innovation-oriented science governance.	Relationship with society is through demonstrable impact, primarily in the ability of R&I to generate economic and user benefit. Engagement as user or consumer, rather than as citizen – thus, engagement is further downstream, and is open only to those who have vested interest in the innovation.	<i>Backward-looking evaluations</i> of responsibility in terms of identifying <i>causal pathways</i> and researchers' explicit goals that are traceable to the impact.
Reflexivity	Responsibility to the collective identity of science as ethical institution.	<i>Output-oriented R&I governance</i> Focuses on social justice and fairness as outcomes of reflexive engagement with the societal challenges R&I are tackling.	Does not mandate societal engagement as it is not considered a necessary part of ethical reflexivity. The lack of societal engagement is morally justified by the assumption that optimal outcomes (ethically, socially) will result from the un-biased deliberation of those with the best access to knowledge.	<i>Forward-looking evaluations</i> of responsibility, evaluations of the <i>hidden conditions that shape and propel research and innovation</i> , which may produce injustices in the future.
Responsiveness	Responsibility to society as a network connecting all actors within the food system.	<i>Process-oriented R&I governance</i> Oriented toward democratizing scientific processes through equality of opportunity offered to all to influence and shape technology for the future.	Shared decision-making and co-production of solutions: empowers society to actively contribute to the shaping of innovation and research at the earliest stages of R&I cycle of priority and agenda setting. Collective responsibility for research and innovation process itself through reasoning together. The complex socio-technical system is characterized by inter-dependency of actors and their actions—and this is what creates conditions for collective responsibility.	<i>Forward-looking evaluation</i> of responsibility as reflexivity and collective dialogue about our <i>future and different paths</i> it might take. Openness to pursue different options for the future based on collective reasoning.

clarity about the intentions and motivations underpinning R&I for sustainable food system; and broaden the framing through which future impacts are evaluated. Therefore, responsibility allocations within a complex food system network should be concerned both with the backward-looking (Accountability and Impact) and forward-looking (Reflexivity and Responsiveness) assessments of responsibility aimed not at assigning blame but ensuring future justice for all. Of course, it remains an empirical question how the governance that advocates that the focus on accountability and impact is complemented by reflexivity and responsiveness might be implemented in practice. Strong governance frameworks specifying procedural aspects including inclusiveness and representation, overseen by clear frameworks

of accounting, may be needed to provide oversight and control against vested interests usurping governance processes (Kraak et al., 2014).

Our study has some limitations. Some categories of stakeholders were more prevalent or accessible than others, and whilst we made efforts to equally represent different stakeholders, this was difficult to achieve. Despite these constraints, it was nevertheless thought less important to equally represent different categories of stakeholders because their categorization and roles varied between R&I domains in ways that made operationalizing these definitions problematic. Rather, it was thought more useful to differentiate on the basis of which types of stakeholders were currently described as influencing research from within

the research process and which were described as existing outside it and requiring access via gatekeepers in order to exert influence. Arguably, with scientists now sitting on funding councils, advising policy makers and consulting for industry, the most significant boundary to be examined no longer lies between the institution of science and everything else. A more useful way to examine the roles of responsibility within food R&I and the concomitant governance processes may be to juxtapose those stakeholders who are currently part of the extended professional infrastructure involved in R&I—not just researchers, but funding bodies, policy makers, industry—with those who are not, for example groups in wider society, and this differed by project.

CONCLUSIONS

Responsibility needs to be re-imagined as a matter of social negotiation; R&I as achieving legitimacy through ethical and social deliberation, aimed at what is (socially, ethically, environmentally) desirable, rather than merely accountable. Our mapping of responsibility rationales as they specifically play out in the context of food R&I, and the identification of the key criteria on which these rationales are differentiated provides a basis for systematic application of these criteria to the specific instances of food systems R&I governance and for future joint decisions, within the food network, about the ways to allocate responsibilities.

DATA AVAILABILITY STATEMENT

The datasets generated and/or analyzed during the current study

are not publicly available. This is because the consent from the participants to re-purpose the anonymized data was given under the condition that the data would only be made available if relevant legal, professional, and ethical approvals were provided. Anonymized data is available from the corresponding author on reasonable request. Requests to access the datasets should be directed to l.timotijevic@surrey.ac.uk.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The University of Surrey Ethics Committee which granted this project a favorable ethical opinion on 19th July 2016 (UEC/2016/031/FHMS). The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LT had an overall responsibility for the study, the design and the analysis of the study, and wrote the article. CH contributed to the analysis and writing of the article. MP collected, analyzed data, and contributed to the writing of the article. MR contributed to the design of the study, analysis, and writing of the article. All authors contributed to the article and approved the submitted version.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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