

Routledge
Taylor & Francis Group

Journal of Responsible Innovation

ISSN: 2329-9460 (Print) 2329-9037 (Online) Journal homepage: www.tandfonline.com/journals/tjri20

Moving downstream in responsible innovation: seven building blocks for responsible scaling strategies

Cees Leeuwis, Mareike Smolka, Hanna Ewell, Erin McGuire, Esther Kihoro, Philipp Neudert, Ebenezer Ngissah, Samuel Mugambi, Marc Schut & Laurens Klerkx

To cite this article: Cees Leeuwis, Mareike Smolka, Hanna Ewell, Erin McGuire, Esther Kihoro, Philipp Neudert, Ebenezer Ngissah, Samuel Mugambi, Marc Schut & Laurens Klerkx (2026) Moving downstream in responsible innovation: seven building blocks for responsible scaling strategies, Journal of Responsible Innovation, 13:1, 2739111, DOI: 10.1080/23299460.2026.2739111

To link to this article: https://doi.org/10.1080/23299460.2026.2739111

© 2026 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group

Published online: 16 Nov 2026.

Submit your article to this journal

Article views: 244

View related articles

View Crossmark data

Citing articles: 1 View citing articles

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=tjri20

JOURNAL OF RESPONSIBLE INNOVATION
2026, VOL. 13, NO. 1, 2739111
https://doi.org/10.1080/23299460.2026.2739111

Routledge
Taylor & Francis Group

RESEARCH ARTICLE

OPEN ACCESS Check for updates

Moving downstream in responsible innovation: seven building blocks for responsible scaling strategies

Cees Leeuwis [a]*, Mareike Smolka [a,b]*, Hanna Ewell [a,c], Erin McGuire [d,e], Esther Kihoro [a,f], Philipp Neudert [b], Ebenezer Ngissah [a,f], Samuel Mugambi [a], Marc Schut [a,f,g,h] and Laurens Klerkx [a,i,j]

[a]Knowledge, Technology & Innovation group, Social Sciences Department, Wageningen University, Wageningen, The Netherlands; [b]Human Technology Center, Faculty of Arts and Humanities, RWTH Aachen University, Aachen, Germany; [c]International Center for Tropical Agriculture (CIAT), Nairobi, Kenya; [d]Plant Sciences Department, University of California, Davis, CA, USA; [e]Responsible Innovations, Sacramento, CA, USA; [f]Impact at Scale Team, International Livestock Research Institute (ILRI), Nairobi, Kenya; [g]Portfolio Performance Unit, CGIAR System Organization, Montpellier, France; [h]Office of Chief Scientist, CGIAR System Organization, Montpellier, France; [i]Departamento de Economía Agraria, Universidad de Talca, Talca, Chile; [j]Center for Advancing Agri-Food System Transformation (CA2FST), Santiago, Chile

ABSTRACT

Responsible innovation (RI) has mainly focused on decision-making in the 'upstream' and 'midstream' of science, technology, and innovation, which emphasize agenda-setting for research and development. The 'downstream,' in which innovations spread and become embedded in society, has received little attention. We argue that RI scholarship and practice should engage in governing the downstream, where decision-making around the scaling of innovations preordains societal impacts. This article introduces the concept of responsible scaling (RS), which denotes practices that reflexively attend to distributed impacts of the implementation of innovations; seek to anticipate unintended effects; involve diverse actors, views, and values; and flexibly steer the spread of innovations in the light of changing circumstances. To promote the development, implementation, and adaptation of RS strategies, we identify seven 'building blocks' and discuss their individual merits. Importantly, RS opens up questions as to how scaling is framed and approached to challenge market imperatives and technological determinism.

ARTICLE HISTORY
Received 30 August 2025
Accepted 21 September 2026

KEYWORDS
Responsible scaling; scaling strategy; systems thinking; agricultural development; Global South

From responsible innovation to responsible scaling

Over the last fifteen years, responsible innovation (RI) has grown into a vibrant scholarly community, which studies and facilitates critical and practical engagement with the early phases of research, innovation, and technology development (Fisher et al. 2024). The original vision of this community, as articulated by some of its founding figures (Owen, von Schomberg, and Macnaghten 2021b), is to align science and innovation with societal values, needs, and concerns, while challenging assumptions of technological determinism and market imperatives. RI research has been conducted in response to public contestation of new and emerging science and technology, such as nanotechnology (Rip 2018), genetic modification (Macnaghten 2016), geoengineering (Stilgoe, Owen, and Macnaghten 2013), synthetic biology (Pansera et al. 2020), digitalization (Fielke et al. 2022), and artificial intelligence (Domínguez Hernández and Owen 2024). This research takes into view phases of research, innovation, and technology development that have 'traditionally been regarded as properly fenced off from social attention' (Macnaghten, Kearnes, and Wynne 2005, 278). The dominant political response to public concerns and contestation has concentrated on regulatory solutions relying on risk assessment and market selection mechanisms applying to technologies that have taken shape already and are rather difficult to change in their design (ibid.). Whereas this dominant response has traditionally engaged with public

CONTACT Mareike Smolka mareike.smolka@wur.nl Social Sciences Department, Wageningen University, Hollandseweg 1, 6707 KN Wageningen, The Netherlands
*Cees Leeuwis and Mareike Smolka share first authorship. They contributed equally to the research and writing of this article.

© 2026 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group
This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. The terms on which this article has been published allow the posting of the Accepted Manuscript in a repository by the author(s) or with their consent.

concerns and contestation 'downstream' (implementation and end use) of research and development, RI seeks to govern 'upstream' (science policy) and 'midstream' (research and development) decision-making (Fisher, Mahajan, and Mitcham 2006, 485).

RI researchers have used this stream metaphor to differentiate their work from the linear model of innovation, a dominant underpinning of science policy which posits that economic and social prosperity is a direct consequence of applied research emerging from curiosity-driven basic research (Macnaghten 2022). While 'the linear model views science as the motor of societal progress' (98), RI researchers use the stream metaphor with its 'eddies, back currents, eroding banks, shifting depths, and whatnot' (Fisher, Mahajan, and Mitcham 2006, 490) to highlight their recognition of the mutual shaping of science, technology, innovation, and society.[1] This recognition has given rise to theoretical inquiry, empirical research, normative appraisal, and collaborative engagement through which RI stimulates reflection on the distributions of benefits and disadvantages – potential 'winners' and 'losers' – at a stage when innovations are still malleable and relatively easy to change (Collingridge 1980). Based on such reflection, RI encourages actors in the research and innovation system to adjust courses of action despite limited knowledge and control.

Locating their work in the upstream and midstream, RI researchers have primarily focused on studying and engaging with science policy, funding organizations, universities, research institutes, start-ups, research departments of companies, and other research and development settings. This emphasis, however, evokes the impression that as long as attention is paid to RI dimensions – anticipation, reflexivity, inclusion, and responsiveness (Stilgoe, Owen, and Macnaghten 2013) – in these settings, innovation processes and outcomes will be responsible. This way of thinking neglects that outcomes are also shaped by decision-making in the downstream, where a technology, product, or service has taken a particular form and is about to be implemented in specific contexts of application. In this respect, Tait (2017) has identified the 'clear need now to move beyond the focus on the research community and to consider the very different issues faced in more downstream innovation processes' (9). Downstream considerations related to the *scaling of innovations* inform the decisions of those who seek to expand the use of novel technologies, products, or services. While its definition is itself contested, 'scaling' can be understood as the expansion, adaptation, and sustained use – deliberate or emergent – of innovations across communities of actors and/or geographies (Schut, Leeuwis, and Thiele 2020).

The scaling of innovations has been identified as a thus far neglected yet important topic of investigation in RI literature (Bruce and Bruce 2019; Lubberink et al. 2019; Sideri 2024; Wiarda and Doorn 2023). Such investigation is particularly relevant to three branches of RI scholarship and practice: RI in industry (1), innovation ecosystems (2), and the Global South (3):

(1) Literature on RI in industry points out that actors across the value chain make decisions about where and how to produce, package, and distribute new technologies (Lubberink et al. 2019; Smolka et al. 2024b). These decisions preordain the societal and environmental impacts of producing and spreading a technology at scale. As observed by Lubberink et al. (2019), however, RI 'neglects the crucial stage of implementing the innovation and scaling for impact' (180). This stage is crucial because scaling may undermine the societal impacts that have motivated innovations in the first place.
(2) Emerging scholarship on 'responsible innovation ecosystems' (Stahl 2022) acknowledges that impacts cannot be attributed to the use of a single technology in a bounded environment, but instead needs to be understood as emergent within socio-technical systems, in which socio-organizational and institutional innovations go hand-in-hand with technology development, scaling, and adoption. But socio-technical systems characterized by sustained deployment of new technologies, such as artificial intelligence (Stahl et al. 2023) and mRNA vaccines against COVID-19 (Sideri 2024), have been shown to exacerbate existing local and global inequalities, which signals the relevance and urgency of developing responsible approaches to scaling.
(3) Research on RI in Global South contexts indicates that developing responsible approaches for the scaling and adoption of mature innovations – for example for urban and agricultural development – may be more pressing in these contexts than improving the governance of new and emerging technologies (Macnaghten et al. 2014).

Building on this literature, we aim to respond to the following question formulated by Pfotenhauer et al. (2022): 'How can we, rephrasing Collingridge's (1980) dilemma of control, govern emerging technologies [and other innovations] from the point where changes are easy but consequences are unclear, to the point where the consequences are mostly clear but change has become hard, in a way that always emphasizes plurality of options and configurations along the way [?]' (23–24). To this end, we suggest that the RI community can learn from efforts to study and enhance scaling in international development contexts, i.e. donor-driven efforts to enhance the spread of novel technologies or practices in Global South contexts (Gebreyes et al. 2021; Westermann et al. 2018; Wigboldus et al. 2016; Wigboldus and Leeuwis 2013; Woltering 2024). Most of these efforts have emerged in agricultural development settings, in which (inter)national research organizations, intermediaries, and development NGOs are under strong pressure to scale innovations and demonstrate development impact along the lines of international Sustainable Development Goals (Leeuwis, Klerkx, and Schut 2018). Based on research in these settings, scholars have introduced the concept of 'responsible scaling' and have developed methods to put it into practice (Kihoro et al. 2025; McGuire et al. 2024b; Wigboldus et al. 2016; Woltering et al. 2024). We believe that this concept and these methods can be relevant beyond agricultural development settings in view of recent agenda-setting work in science and technology studies (STS) and innovation studies that point to the need for paying more attention to the societal dimensions of scaling (Pfotenhauer et al. 2022; Robinson, Borrás, and Boon 2025) and wider debates on 'just transitions,' in which the scaling of innovations plays an important role (Stark, Gale, and Murphy-Gregory 2023; Tschersich and Kok 2022; Wang and Lo 2021).

Informed by research on international agricultural development and emerging debates on responsible scaling in other fields (e.g. Boon 2025; Lukkien et al. 2025), we seek to answer the following research question: *What are the conceptual building blocks, operational strategies, and methods for enacting responsible scaling?*

To address this question, we first conceptualize responsible scaling (RS) in relation to RI. We then propose that RS can be facilitated through iterative practices of developing, implementing, and adapting RS strategies. To guide these practices, we introduce seven 'building blocks' that can be associated with RS strategies and suggest particular methods pertaining to different building blocks based on a narrative literature review. We conclude by elaborating on academic contributions to bodies of literature on RI in industry, innovation ecosystems, and the Global South, which have pointed to the relevance of the study of scaling in these contexts. We finally discuss avenues for future research and reflect on opportunities for approaching RS as part and parcel of RI.

Conceptualizing responsible scaling

To conceptualize RS, we first present below the hegemonic linear model of scaling and its critiques. Next, we introduce RS as a concept denoting a constructive and practical response to these critiques.

Linear model of scaling

Expanding on the abovementioned linear model of innovation, contemporary innovation discourses assume innovation and its large-scale, rapid spread in society as necessary for economic growth and societal benefits. In the pursuit of such '*Blitzscaling*' (Hoffman, Yeh, and Gates 2018; cited in Pfotenhauer et al. 2022), companies seek to spread an innovation swiftly and at a large scale, without performing the labor of adjusting technological and social evolutions and thus risking profound social disruptions. Such disruptions have emerged worldwide in consequence of the rapid scaling of platform technologies like Facebook, Twitter, and Uber. Nevertheless, the imperative to scale has maintained its tractive force in both private and public sectors. In public policy, the scaling of innovations is thought to help address pressing societal challenges and global issues, such as climate change (Laurent and Violle 2024). Accordingly, policymakers are eager to demand the scaling of solutions – developed and tested in pilot projects, living labs, and other experimental spaces – to contribute to sustainability transitions.

The contemporary 'obsession' with scaling is hardly new: it has long been critical to many efforts aimed at modernization and development. Over the last two centuries, scaling has been a matter of industrial expansion: producing and distributing a high number of standardized goods in order to maximize

economic profits (McLean and Gargani 2019). The spread of new ideas or technologies was earlier referred to as 'diffusion of innovations' (Rogers 1962), a concept that became widely deployed across academic disciplines, technology development, and management consultancy. Diffusion can be seen as a precursor to scaling and has come to be used synonymously (cf. Robinson, Borrás, and Boon 2025). In the 1980s, NGOs in development contexts started using the term 'scaling,' linking it to the expansion of positive social impact (Wigboldus 2018). The scaling of innovations for development was fueled by the Sustainable Development Goals. The United Nations (2015) framed the scaling of modern technology as a promising way to eradicate poverty and protect the planet. In a similar vein, funding organizations and donors supporting research and innovation for global development have come to equate the large-scale adoption of innovations with impact (Leeuwis, Klerkx, and Schut 2018). To achieve large-scale adoption of technology, innovators, and change agents have looked for best-practice models of scaling to replicate them elsewhere (cf. Pfotenhauer and Jasanoff 2017).

This way of thinking about scaling reveals an assumption of linearity, as grounded in three premises (cf. Woltering 2024): first, innovations originate in basic science, move into applied research and development, and enter society at a later stage of widespread adoption; second, this process proceeds in a rational, step-wise manner that can be replicated across contexts; and, third, there exists a linear relationship between high adoption of innovations and positive impact. These premises have been scrutinized by systems thinkers and STS scholars who have analyzed the problematic implications of the linear model of scaling.

Critiques of the linear model

Several forms and generations of systems thinking in innovation studies (Checkland 1981; Edquist 2013; Hall and Clark 2010; Hekkert et al. 2007; Klerkx, van Mierlo, and Leeuwis 2012; Lundvall 2010; Röling 1988) have raised numerous critiques of linear models of innovation and scaling (Kline and Rosenberg 1986; Leeuwis 2004).[2] Early critiques address technocratic and top-down framings, which obscure feedback loops from practice to research in innovation systems (Röling 1988) and ignore the importance of participatory approaches to enhance the relevance of innovations to users and stakeholders (Buur and Matthews 2008; Fleck 1993; Jiggins and de Zeeuw 1992; Nygren, Zukauskaite, and Westberg 2018; von Hippel 2005). Other critiques recognize that best-practice models of scaling are biased toward promoting particular (capitalist) models of development, brushing over contextual differences and diversity in society (Bruland and Mowery 2014; Ritzer 1996; van der Ploeg 1990). Later critiques center around the focus of scaling initiatives on technological innovation, which neglects social-organizational and institutional dimensions of innovation (Foxon 2002; Glückler and Bathelt 2017; Hall and Dijkman 2019; Hounkonnou et al. 2012).

A prominent cross-cutting and long-standing critique to the linear model is that of a 'pro-innovation bias' (Rogers 1962, 92), which refers to the abovementioned premise that innovations are inherently worthwhile and likely to yield socially beneficial impacts. Empirical research has shown that social impacts often motivate research and innovation for international development but tend to fade into the background in the process of scaling (Wigboldus 2018). As impact is often measured in terms of numeric and geographic reach of a product or service, the ways in which it shapes everyday life and gives rise to unintended harmful side-effects tend to disappear from view (Biggi and Giuliani 2021; Bucic and O'Connor 2024; de Roo et al. 2019; McGuire et al. 2022, 2024a, 2024b; Schut, Leeuwis, and Thiele 2020).

A critique of scaling formulated by Tsing (2012), which is widely known in STS communities, draws attention to such harmful effects. Tsing observes that the modern world has been shaped by 'scalability projects' (507), ranging from plantation agriculture to industrial manufacturing. Tsing defines scalability as the ability to expand a product or service without revising basic elements. Accordingly, scalability projects approach the world as a set of 'uniform blocks, ready for further expansion' (506). In being treated as uniform blocks, specific elements of the world – such as plants and workers – become interchangeable, alienated objects and subjects of control. Efforts to control nature and humans have had destructive environmental and societal consequences. Building on Tsing, scholars have considered alternatives to scalability, such as small-scale technologies that make a big impact on people's lives but fall outside the scope of modern industrial imaginaries (Anantharajah 2024) and local open-source projects, which share knowledge and resources in global digital commons (Kostakis, Lemos, and Kouvara 2024).

Furthermore, STS scholars have analyzed and critiqued the omnipresence of scalability in twenty-first-century innovation policy. Accordingly, some policymakers assume that participatory forms of innovation in 'real-world experiments' can produce scalable solutions to grand societal challenges (Engels, Wentland, and Pfotenhauer 2019). In this respect, Macq, Parotte, and Delvenne (2021) have indicated, however, that 'the universal promise of scalability is always at risk of disappointment' (164) because the specific social, material, and political arrangements at the site of experimentation are critical to the adoption of an innovation. Similarly, Pfotenhauer et al. (2022) have analyzed the 'misguided promises of ready-made transferability and scalability' (13) in sustainability transitions. In light of such promises, regulation is lowered or lifted to deploy new technologies under real-world conditions. Pfotenhauer et al. concern themselves with the 'politics of scaling' in specific empirical cases, asking how the logic of scalability gains dominance and credibility, who benefits from it and who is put at a disadvantage by it, as well as how it shapes wider political economies. Informed by this concern, Laurent and Violle (2024) problematize the scalability imperative by investigating the plurality of what scaling means in practice. They trace empirically how small-scale experiments with hydrogen cars do not fulfil expectations of *Blitzscaling* but instead expand across regions through the mushrooming of ecosystems of hydrogen mobility.

Responsible scaling

The plurality of scaling is captured by the concept of RS.[3] The concept was introduced by systems thinkers in international agricultural development (Wigboldus et al. 2016; Wigboldus and Leeuwis 2013; Wigboldus, Klerkx, and Leeuwis 2020), a field characterized by a long history of scalability projects of various kinds. Scalability became associated predominantly with the expansion of agricultural technologies, products, and services, such as plantation agriculture in colonial times (Tsing 2012), and improved crop varieties, as well as the large-scale use of fertilizers and pesticides associated with the Green Revolution in the twentieth century (Borlaug 2000). Since agriculture is necessarily situated and dependent on local conditions, such indiscriminate advancement and scaling has resulted in various local and global sustainability challenges and critiques (Andersson and Giller 2012; Dawson, Martin, and Sikor 2016; Pimentel 1996; Sumberg, Thompson, and Woodhouse 2012; Tsing 2012). In response to such challenges and critiques, agricultural models – such as sustainable intensification (Vanlauwe et al. 2014), agro-ecology (Altieri and Nicholls 2012), and conservation agriculture (Hobbs, Sayre, and Gupta 2007) – have been put forward in recent years. However, these have also attracted debate as to their suitability and whether or not they should be massively scaled (Bless, Davila, and Plant 2023; Mockshell and Kamanda 2018; Sumberg and Giller 2022). These features and contestations render the agricultural domain particularly suited for reflection on scaling and how it can become responsible.

Moreover, the work of authors pioneering RS in this domain is of particular relevance because it was informed by the four-dimensional RI framework formulated by Stilgoe, Owen, and Macnaghten (2013) and has given rise to an emerging RS community of researchers and practitioners,[4] which bears resemblances to the intellectual movement that formed around RI (Shanley 2022). RS describes practices that seek to anticipate unintended effects; reflexively attend to distributed impacts of the implementation of innovations; involve diverse actors, views, and values; and flexibly steer the spread of innovations in the light of changing circumstances. Responsibility in the context of scaling includes, then, 'awareness about potentially undesired consequences of scaling processes that might have been anticipated and then could have informed different decision-making' (Wigboldus et al. 2016, 527). To generate such awareness, in particular among decision-makers who shape scaling processes, RS requires collaboration with those who may be affected by the implementation of innovations in unintended ways. It shares the collaborative and democratic ethos of RI and should thus not be confused with recent attempts to define responsible scaling of artificial intelligence in terms of narrowly framed risk management (Anderson-Samways et al. 2024; Hubinger 2025). Instead of adopting a narrow focus on risk, RS takes 'just transitions' (Stark, Gale, and Murphy-Gregory 2023) into view, attending to fair and equitable processes and outcomes of scaling innovations.[5]

In moving downstream, RS does not assume a smooth, straight, singular, and even flow. Instead, RS recognizes that streams may form meanders, go through turbulences, and flow in swirling motions around rocks and banks; they may separate in complex networks of distributaries or may be joined by other streams. In a similar way, research and development may move back and forth in a zig-zag motion between basic and applied (Mody 2016), while technological trajectories may split up appearing in different versions at

different local sites (de Laet and Mol 2000). Although the stream metaphor challenges linear models of innovation and scaling, it does not contradict a somewhat linear spread of innovations from one site, community, and/or scale to another. After all, a stream can overflow, spilling out of the channel and moving sediment to floodplains, or flood wider areas of land. In that vein, the abovementioned critiques of the linear model of scaling do not critique linearity per se (i.e. the spread of innovation following a growth pattern); rather, they criticize hegemonic simplistic assumptions. These assumptions rely on single, uniform visions of progress and imply that a specific technology, product, or service design could be adopted across contexts (Stirling 2009, 2011).

Critics have debunked these assumptions by showing how the scaling of innovations depends on a plurality of place-based ontologies, epistemologies, and practices whose conditions for social desirability, legitimacy, and robustness need to be continuously probed (Bögel et al. 2022; Dijk, de Kraker, and Hommels 2018). Probing may lead to adjustments in scaling and a diversification of types of scaling, which can co-occur and relate in diverse ways to one another. Examples are 'scaling out' (involving broader social and/or geographical categories and communities), 'scaling up' (creating enabling policies and institutional conditions), 'scaling deep' (addressing ingrained mental models and interpretative paradigms that hinder scaling), and 'scaling down' (phasing out of pre-existing technologies, practices, and conditions that enable these) (Lam et al. 2020; Moore, Riddell, and Vocisano 2015; Schut, Leeuwis, and Thiele 2020; Wigboldus et al. 2016; Wigboldus, Klerkx, and Leeuwis 2020; Woltering 2024). Scaling in RS, then, refers to a diverse set of fluid processes that are closely interrelated with and responsive to spatial and social dynamics.

The decisions made in upstream science policy and midstream research and development differ from the decisions relevant to downstream processes of scaling. Downstream decisions tend to be less anticipatory and more practical in nature. They can involve trade-offs or compromises between different scaling objectives (for example, between profit and sustainability); the prevention, compensation, or management of 'hidden implementation costs' (Boon 2025, 10) of creating novel infrastructures, work flows, and trainings for an innovation to work in specific contexts; and engagement with the consequences of exnovation (i.e. the phase-out of the practices or technologies that an innovation replaces, see David and Gross 2019), to name but a few examples. Such decisions may be anticipated in technoscientific projects with an RI component, but responsibility for making these decisions is often postponed into the future and/or deferred to industry or policymakers (Smolka et al. 2026).

For this reason, a novel set of methods is required if scaling initiatives are to contribute to making such decisions responsibly (Ewell, Smolka, and Leeuwis 2026). Some of these methods take initial observable effects of mature innovations – effects that are usually anticipated in early phases of innovation processes – as a starting-point to assess their desirability from the perspective of diverse social groups. This assessment informs actions that amplify or counteract these effects. Such assessment and its corresponding actions cannot be realized by technoscientific practitioners alone. In other words, raising reflexive awareness among technoscientific practitioners – the focus of many RI approaches (Fisher et al. 2015; Reijers et al. 2018; Schuijff and Dijkstra 2020) – is not sufficient. Scaling experts with diverse backgrounds (economics, business, innovation studies, sociology, international development research and practice, strategic communication, etc.) as well as a wide range of scaling stakeholders and change agents have been involved in RS efforts (Ewell, Smolka, and Leeuwis 2026). We suggest structuring the involvement of diverse actors and the deployment of RS methods according to a tailor-made, situated scaling strategy.

Toward responsible scaling strategies

As visualized in Figure 1, we propose that RS strategies are constituted through decisions that can be framed in terms of seven 'building blocks,' resulting from an iterative co-creation and investigation process among a set of relevant actors. The building blocks are inspired by well-established scaling-oriented planning approaches used in agricultural extension (i.e. information and advisory service for farmers, see Leeuwis 2004; van den Ban and Hawkins 1996) that are congruent with approaches used in other fields, such as health promotion (Bartholomew et al. 2016/2017; Koelen and van den Ban 2004). Although scaling strategies need to be contextually adapted and developed, experiences in these fields suggest that the building blocks in Figure 1 always merit consideration.

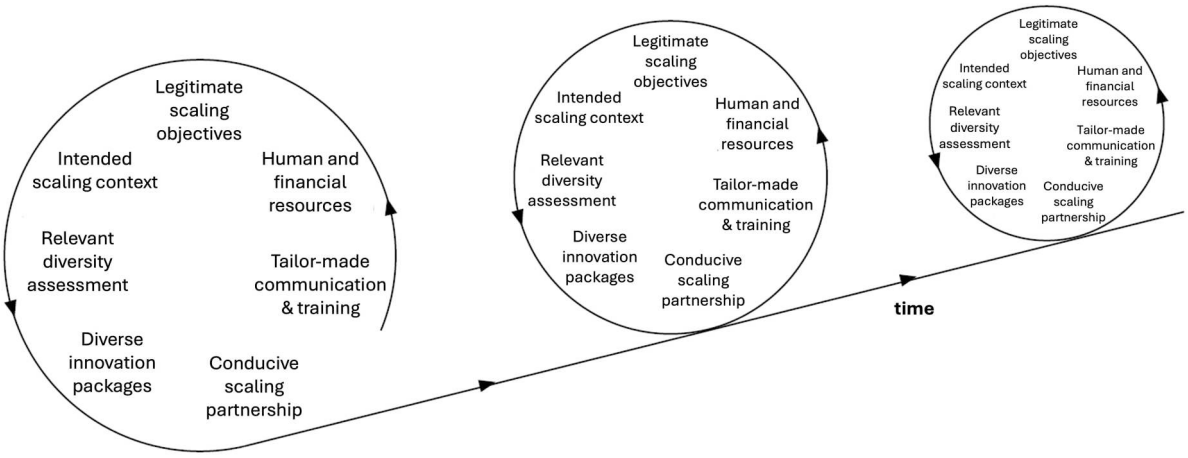

Figure 1. Iterative co-creation and investigation practices summarized in building blocks for the development, implementation, and adaptation of scaling strategies constitute a process that dynamically unfolds over time in view of progressive insights and changing conditions.

Based on a narrative review of the emerging body of literature on RS in international agricultural development, we have focused and elaborated on commonly used building blocks for scaling strategies through a responsibility lens. A narrative review is an interpretive approach to sorting out and integrating literature (cf. Bourhis 2018; Jamal et al. 2013; Sukhera 2022). Such a review may be considered as less rigorous and more subjective than a systematic review. At the same time, a narrative review is more sensitive to specific traditions, fields, and areas of research. It is therefore particularly useful to gain a better understanding of a specific topic (RS strategies) from a contextual point of view (international agricultural development). As discussed above, this field has provided fertile ground for discussions about RS due to the tension between, on the one hand, the inherent dependence of agriculture on locally specific conditions, and, on the other hand, past experience within this field with the spread of scalability projects, which tended to promote rather uniform models of agricultural development. Despite this contextual point of view, the examples we use to illustrate aspects and concepts pertaining to our seven building blocks do not focus on agriculture alone, but also on energy, health, computing, mobility, and telecommunication. To this end, we complemented the narrative review with a targeted search for a variety of scaling examples to indicate the wider relevance of RS strategies for diverse innovations, contexts, and audiences.

Although we use the concept of 'strategy,' which is commonly defined as 'a long-range plan for achieving something or reaching a goal' (Cambridge Dictionary 2025),[6] we do not conceive of scaling strategies as centrally developed blueprint plans. A scaling strategy does not rely on a fixed set of interventions that promise to successfully induce RS. Instead, we acknowledge that scaling tends to take place over a prolonged period of time, involves multiple actors, and cannot be centrally controlled and predicted. This is why the iterative practices of developing, implementing, and adapting scaling strategies are crucial to RS: the ongoing deliberation and information gathering to reach agreement about building blocks and the resulting alignment of action plans among actors on whom RS eventually depends (McGuire et al. 2024b; Reichelt and Nettle 2023).

Iterative co-creation and investigation practices enable inclusion of relevant actors and expertise in deliberation and decision-making, and they allow for anticipation, reflexivity, and responsiveness that characterize RI (Stilgoe, Owen, and Macnaghten 2013). Through these practices, diverse scaling strategies emerge depending on how the building blocks are ordered, shaped, and made coherent in particular contexts. The constitution and composition of building blocks may be facilitated by the use of specific methods. These methods guide and enhance iterative co-creation and investigation practices for particular issues relevant to scaling. In our discussion of the building blocks below, we provide some examples of methods developed in recent years. For this article, we selected methods the contributions of which to decision-making in specific building blocks are well-documented. Our examples are far from exhaustive and merely serve as illustrations that highlight the potential and usefulness of method development.

Seven building blocks

Legitimate scaling objectives: balancing primary and complementary goals and interests

From an RS perspective, the scaling of innovations is not a goal in itself, but rather a means to achieve specific outcomes.[7] Agricultural development organizations, for example, typically try to scale new seed varieties or soil fertility management practices to enhance food security, combat poverty, reduce environmental degradation, or promote equity (Low and Thiele 2020; McGuire et al. 2024a; Vanlauwe et al. 2015). Similarly, public authorities may promote the use of solar panels on private houses either to reduce CO_2 emissions in the Global North (Kapsalis et al. 2024) or to promote wellbeing and health (i.e. avoid inhalation of damps associated with kerosene lamps) in places without an energy grid (Ortega et al. 2021). Moreover, in situations where scaling is driven mainly by private sector companies or start-ups, scaling tends to be seen as a means to achieve larger company objectives, such as generating profit, boosting shareholder value or attracting investment capital, and aligning economic value creation with societal value creation (Lange et al. 2023).

A variety of interdependent actors, including both public and private sector parties, tend to be involved in processes of scaling. To give an example from the context of agriculture: publicly funded breeding programs that cannot scale new seed varieties without the help of private seed multiplication or distribution companies (Donovan et al. 2021). In healthcare systems, pharmaceutical companies may need to obtain licences and contracts with public health insurance bodies to be able to scale the use of new medical products. In different settings, then, networks of different parties pursue a variety of goals, whereby it is likely that trade-offs and tensions exist, for example between economic value creation and social equity. For purposes of developing RS strategies, it is useful to consider that often, at one point, an initiating party with a certain degree of ownership or power (legal or otherwise) over a particular innovation will formulate a scaling ambition. The scaling objectives of the initiation party we label as 'primary scaling objectives,' whereas the objectives and interests of others in the network feature as 'complementary objectives' relevant to the overall scaling endeavor.[8]

Regardless of whether the initiator is private or public, we argue that an important requirement for RS is that primary and complementary scaling objectives become (a) transparent, (b) subject to deliberation, and that (c) the balance between objectives strived for must somehow be considered legitimate (McGuire et al. 2025; Sánchez Rodríguez et al. 2021; Woltering et al. 2019). The latter means that the primary and secondary scaling objectives must be found appropriate by a forum that can legitimately represent stakeholder and public interests in the context at hand. From this perspective, for example, it would not be responsible for either a publicly funded international research organization or a private sector company to work toward scaling innovations geared to agricultural intensification in a country that has democratically decided to go for an extensive agro-ecological future. In such a situation, a scaling strategy directed at boosting agricultural productivity per hectare through the use of high levels of chemical inputs may still be legally permitted, but the scaling objective cannot be regarded as responsible. The mechanisms and fora through which legitimate decisions about scaling objectives can be made may not always be self-evident, as they will differ across contexts, may not be formalized, and can be subject to dispute. Nevertheless, RS initiatives need be able to explain through what process and mechanisms legitimacy has been obtained, and why these are appropriate. We propose that methods for stakeholder and public participation (see examples in Box 1) can facilitate legitimate negotiations of and decision-making about scaling objectives.

Box 1: Methods for stakeholder and public participation

Almost all scaling support methods in agriculture start with a set of questions aimed at deliberating and clarifying the purposes and ambitions associated with a scaling initiative. The Scaling Scan (Jacobs et al. 2018; Woltering et al. 2024), for example, raises several questions as to the 'what, why, for whom, where, when, how many, and by whom' of scaling. It also invites participants to do a 'responsibility check' on social issues (e.g. on handling diversity, inclusion, responsiveness, and empowerment), as well as environmental issues (e.g. considering sustainability, trade-offs, and uncertainties). However, current methods pay little explicit attention to defining who should be involved in such deliberations, and what methods should be employed to guarantee their quality (for an exception, see GenderUp described in Box 2). In most approaches, the idea is that the initiators bring together relevant project staff, partners, and bodies of expertise to discuss questions regarding scaling objectives and possible trade-offs in a facilitated workshop setting (e.g. McGuire et al. 2024b; Reichelt and Nettle 2023; Woltering et al. 2024). While discussions in project workshops can be useful and insightful, they may not automatically be a legitimate forum for representing stakeholder and public interests. More attention is needed for liaising with existing democratic fora or guaranteeing broader engagement. Here RS efforts may benefit from approaches developed in RI, drawing inspiration from methods such as mini publics (Capurro et al. 2015), social labs (Marschalek et al. 2022), and focus groups with different stakeholders (Macnaghten 2020). Typically, such methods engage reflexively with how stakeholder groups and publics are constituted (Chilvers and Kearnes 2016; Douglas et al. 2024) and make efforts to include diverse voices, provide relevant and accessible information, and develop formats that mitigate the exclusive effects of power differentials between participants in deliberation. Such methods can also serve to elicit more refined insight into the intended scaling context.

Intended scaling context: understanding diverging conditions

The consequences of scaling a particular innovation may vary from one context to the next, as shaped by bio-material, economic, socio-cultural, and other dynamics and conditions. Depending on such conditions, the distribution of benefits and disadvantages engendered by an innovation may vary. For example, a labor-saving innovation may aggravate unemployment in situations where alternative jobs are scarce (Hyötyläinen 2022), but in another context such innovation may reduce the exploitation of marginalized or disadvantaged groups (Singh, Gite, and Agarwal 2006; Vemireddy and Choudhary 2021). Similarly, regions with abundant availability of surface water for cooling may benefit from the establishment of data centers through the employment opportunities they bring, whereas the introduction of such infrastructure may reinforce conflict about the appropriate use of water in regions where water is scarce (Hogan 2015). For a scaling strategy to be responsible, therefore, contextual differences need to be considered. In other words, the intended scaling context should be identified and understood.

It is thereby important to consider that the bio-material, economic, socio-cultural, political, historical, and other conditions may vary in different parts of the intended scaling context. A specific country or geographical zone may consist of different subregions where conditions for scaling are meaningfully different (e.g. due to variations in climate, infrastructure, service provision, culture, or population density), thus making it plausible that distributed consequences may differ across regions. Therefore, it is important to clearly define and carefully select the boundaries of the intended scaling context. Knowledge about the scaling context is also important for determining the legitimacy of scaling objectives discussed above; after all, a set of scaling objectives may be considered legitimate in one context but not in another (Hall, Bachor, and Matos 2014).

Relevant diversity assessment: anticipating consequences for different social groups

In any scaling context, there will be social differences that are likely to influence who is willing and able to use and benefit from an innovation, and who is unlikely to benefit from it or, worse, who is likely to face negative consequences of scaling. In the sphere of agricultural development, there are many examples of innovations that result in positive outcomes for men, but that have detrimental effects on women in farming households (McGuire et al. 2022). Similarly, digital innovations aimed at informing large public audiences can have exclusionary consequences for groups with lower digital literacy (McCampbell et al. 2021; Zapletal et al. 2023) and for groups less represented in the training of artificial intelligence applications (Benjamin 2019; Chun 2024). More generally, Criado-Perez (2019) indicates that numerous, already scaled everyday technologies (e.g. automobiles and medical drugs) have discriminatory consequences for women because they were created on the basis of knowledge about male bodies. In other words, negative consequences for specific social groups emerge through the scaling of technology designed with a particular user group in mind.

Differences between social groups are best anticipated early, when deploying RI methods and principles. Once an innovation has been further developed, an RS strategy must interrogate for whom it can and should be scaled or whether research and development should start over again to develop a technology with wider applicability. It also involves asking questions about how the scaling of innovations relates to the destabilization or phase-out of existing practices, products, services, and industries, and who experiences losses and pain inflicted by such exnovation (Bogner et al. 2024; Lonkila et al. 2024; Rinscheid et al. 2021). Recognizing and identifying relevant differences between social groups is important to prevent or mitigate unintended negative consequences (see 'diverse innovation packages' below).

While it is clear from the above that social differentiation is important, it is often not self-evident from the outset what kind of diversity actually matters in relation to a scaling initiative (McGuire et al. 2024b). People can be distinguished and differentiated along a variety of dimensions (age, wealth, education level, culture, religion, land tenure, social capital, gender, health, household composition, employment status, aspirations, location, etc.). Which dimensions are relevant in relation to a scaling initiative depends on the features of the innovation, the scaling objective, and contextual factors (Badstue et al. 2018; Glover et al. 2019; Rietveld and van der Burg 2021). For a capital-intensive innovation, one may usefully need to consider and anticipate different wealth categories among potential users, whereas differences in household or family size can be more relevant when an innovation requires a

lot of labor. A deliberative process is needed to discover the dimensions that matter in a specific context. We provide an example of a method facilitating such a deliberative process with the help of poster templates and probing questions in Box 2. These probing questions stimulate reflection on how dimensions of diversity may shape (i) differential access to resources that are needed to use and benefit from the innovation, (ii) unequal distribution of positive and negative consequences resulting from innovation use at the level of actors involved and affected, and (iii) community or landscape level consequences (e.g. environmental degradation or oversupply of produce) that may result from large-scale use of the innovation.

Box 2: A method for discovering relevant dimensions of diversity

Several scaling support methods in agriculture encourage discussion about how different social groups may or may not benefit from the scaling of an innovation. Against this backdrop, the GenderUp conversational method (McGuire et al. 2024b) is unique in that it pays attention to discovering what dimensions of diversity are relevant in the first place. To this end, members of an innovation team and their key scaling partners are asked to fill out a survey in which they first select all resources needed to access and use the innovation from a long list. Subsequently, they are provided with a list of possible dimensions along which people may differ, and asked to indicate which dimensions may negatively affect access to each of the resources selected as needed for access and use in the previous round. The data of all respondents are then aggregated, and the outcomes visualized in bar charts. These quantitative results are subsequently used as an input for a more qualitative and interpretative discussion about the most important dimensions of diversity that need to be taken into account, resulting eventually in the identification of intersectional social groups that are unlikely to benefit from the scaling initiative unless affirmative action is taken. A poster template, such as the miro board in Figure 2, is used to facilitate this discussion.

On the basis of deliberation and investigation, scaling initiatives can identify intersectional categories that are likely to benefit from an innovation regardless of any special measures (e.g. high income men, with literacy in English, located in cities with good internet access), and also gain insight into intersectional categories that are unlikely to benefit (e.g. low income men and women, with literacy in local languages, located in rural areas with poor internet access) or that are affected negatively (e.g. those whose jobs become redundant by the exnovation that accompanies innovation, see Bouwman, Anderson, and Giller 2021). These latter groups need special attention to ensure that scaling strategies remain responsible, for example by developing tailor-made configurations of multiple innovations (see 'diverse innovation packages' below), alternative opportunities and care for those whose practices are phased out as a result of scaling innovations (Lonkila et al. 2024), and communication approaches that ensure inclusion.

Diverse innovation packages: enabling widespread positive and mitigating negative consequences

It is widely acknowledged that the scaling of a particular innovation is always co-evolving and critically dependent on other changes (Leeuwis and Aarts 2021; Sartas et al. 2020; Woltering et al. 2019). Accordingly, Pfotenhauer et al. (2022) stress that scaling is 'never just "more of the same"' (23) and goes beyond single discrete innovations in the form of new technologies, products, and services. Illustrating this point with the example of autonomous vehicles, the authors explain that this innovation does not solely depend on novel hardware and additional data, but it also alters ways of driving, planning, policing, and maintaining roads as well as communities. In a similar vein, the scaling of mobile phones required the scaling of a lot of other technological infrastructures (e.g. mobile masts, satellite, and cable connections), the roll-out of new legislation and licensing systems for mobile telecom providers, as well as the set-up of a network of mobile phone retailers, repair shops, and (initially) phone credit shops, etc. (Agar 2013; Balbi and Berth 2019).

To capture such co-evolution and interdependence of heterogenous elements, agricultural innovation scholars have promoted systemic perspectives on scaling. These perspectives shift the focus away from isolated innovations and toward 'innovation packages' (Sartas et al. 2020) or 'bundles' (Barrett et al. 2022) of interdependent changes that need to scale more or less simultaneously. Such changes potentially involve not only technological innovation, but also a range of social-organizational innovations, such as novel institutional arrangements, services, or organizational and business models, as well as changes in individual and collective mindsets (Lam et al. 2020).

To develop an effective scaling strategy for achieving desired scaling outcomes, it is thus crucial to recognize complementary innovations and to identify levels of maturity (readiness levels) of such innovations (Sartas et al. 2020), for which we introduce a method in Box 3. An effective scaling strategy

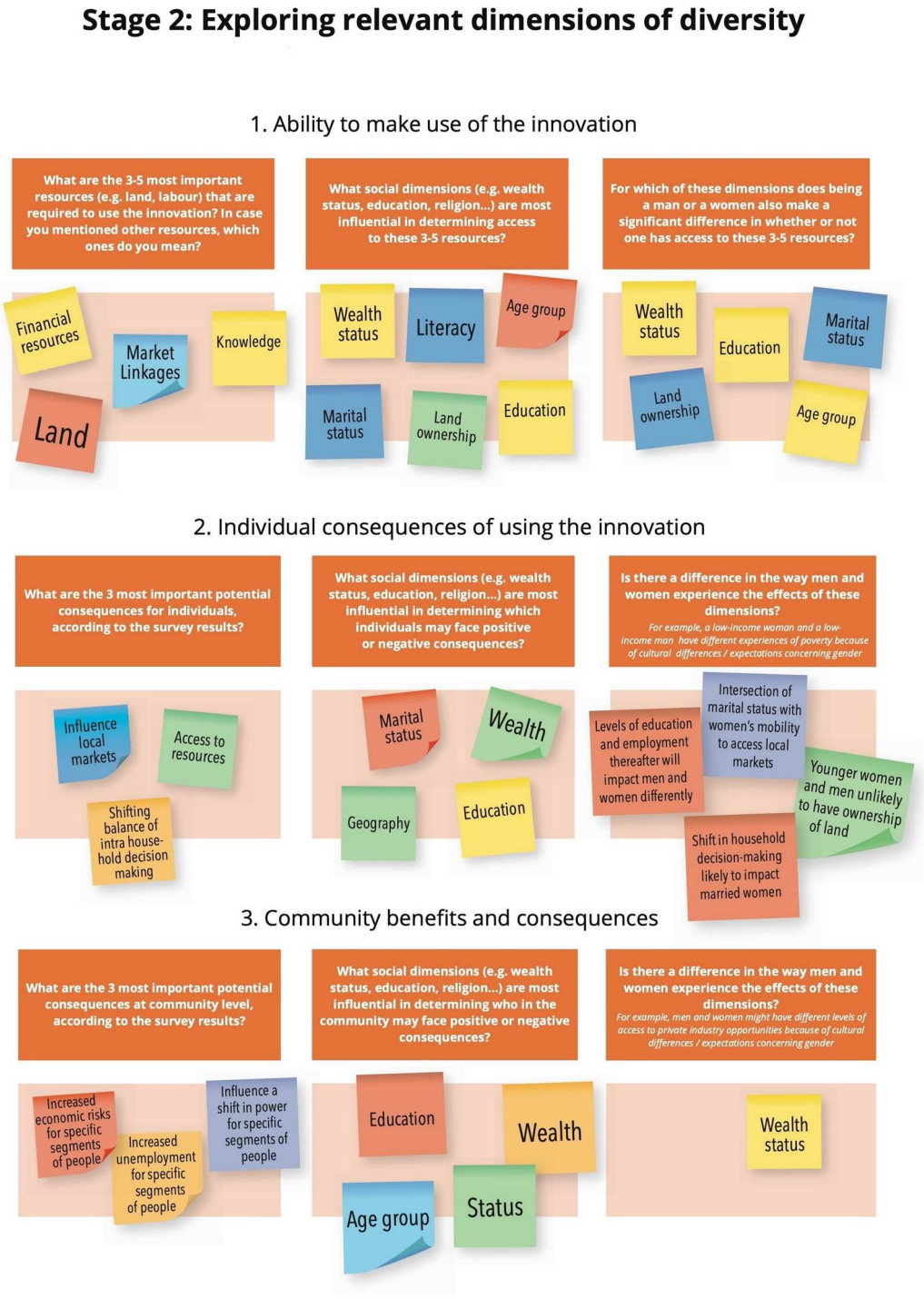

Figure 2. Miro board used to facilitate discussion on relevant dimensions of diversity in a GenderUp online workshop.

further includes interventions and measures directed at promoting complementary innovations. To effectively and responsibly address relevant social differences (as established through an assessment of relevant diversity), it is important that innovation packages are not uniform. Instead, they need to be tailored to the needs and conditions of groups that are at risk of being excluded or facing negative consequences.

Box 3: A method for identifying packages and readiness level

The idea of innovation packages or bundles plays a role in several scaling support methods. In Scaling Readiness (Sartas et al. 2020), this is combined with a process of identifying the most pressing bottlenecks to scaling. First, an innovation team and their scaling partners are brought together in a workshop setting to identify interdependencies in the scaling context. Starting from the core innovation (i.e. the novel technological or social-organizational innovation central to the initiative), participants are asked to consider what other technologies, services, or organizational arrangements need to scale, as well to create an enabling environment for the core innovation. Such changes are labeled 'complementary innovations' (3). Subsequently, participants are asked to assess the level of 'readiness' and 'use' of both the core innovation and all identified complementary changes or innovations. The 'innovation readiness scale' (5) resembles the widely used nine 'technology readiness levels' developed by NASA and adopted by the Horizon 2020 program of the European Union, but it was adapted to fit non-technological innovations. The innovation readiness scale ranges from an unproven idea to an innovation that is proven to be effective for the purpose under everyday conditions. Another nine-point scale called 'innovation use measurement' (5) captures societal support by assessing the scope of the networks that engage with the innovation, ranging from only the project team to direct partners, various circles beyond these, and, eventually, end-users. This results in the placement of all elements in the package in a two-dimensional matrix (Figure 3). The elements with the lowest level of 'readiness' and 'use' are seen as 'bottleneck innovations' (4) that need to be either developed further, or – if possible – replaced by other elements to enhance the viability of the package as a whole. The assessment of elements in the package on the two scales can be done with various degrees of rigor and supporting evidence. Moreover, based on a relevant diversity assessment (as discussed earlier), different packages can be identified and assessed for different social groups and/or different parts of the intended scaling context to foster RS. Using this method can result in novel insights regarding systemic interdependencies and priority areas of action.

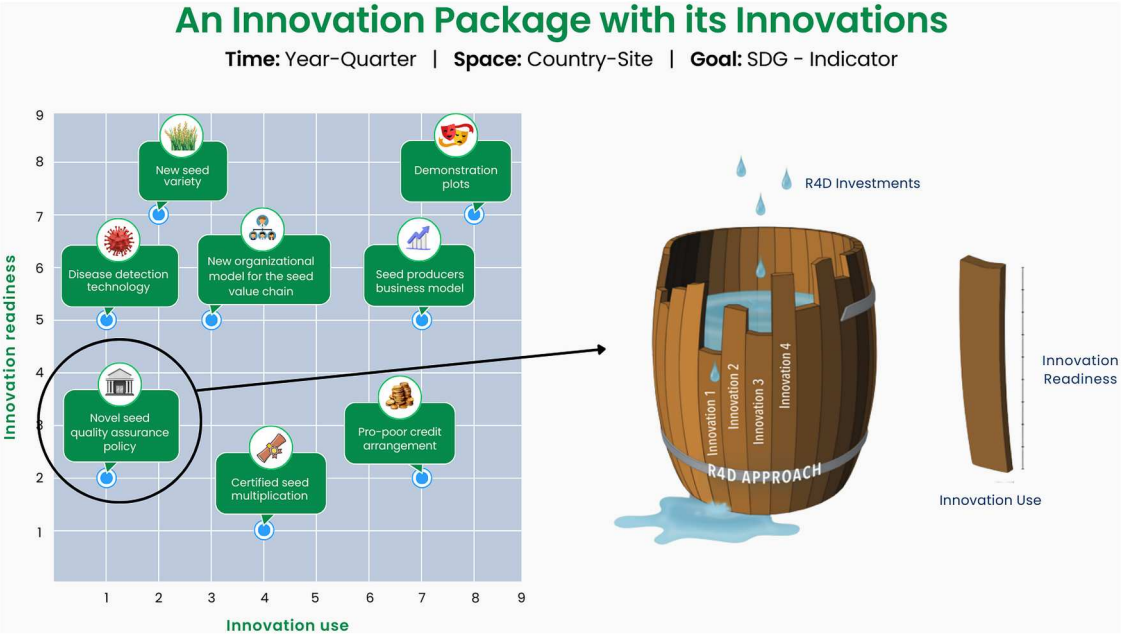

Figure 3. Scaling readiness matrix adapted from Sartas et al. (2020).

Conducive scaling partnership: aligning partnerships with diverse innovation packages

Parties that initiate and pursue the scaling of innovations cannot achieve such scaling alone, nor should they ever aim to do so. Rather, they need to establish relations and coordinate activities (formally or informally) with others. These will often include retailers, service providers, intermediaries, public authorities, or value chain parties, as well as potential users and those who might be excluded or negatively affected. To enable RS, it is important that the partnership is well-aligned with the diverse innovation packages needed to prevent exclusion and mitigate negative consequences. To provide an example that highlights the relevance of aligning partnerships with diverse innovation packages, we consider solar panels which are scaled with the aim of improving the wellbeing and health of rural communities, which, at present, are dependent on kerosene lamps. In this example, one may need to consider that poorer households may not be able to afford the initial investment or buy a new battery every few years (Baurzhan and Jenkins 2016; Oria et al. 2014). For this group, therefore, the innovation package may need to include a business model in which solar systems are owned by a collective or company, with users paying a monthly fee, a pro-poor micro credit facility, or the establishment and organization of saving mechanisms (Oria et al. 2018). For

the provision of a pro-poor micro credit or saving mechanism, parties that can provide or develop such services need to become effectively involved in the scaling process (Sartas et al. 2020). Such involvement does not arise automatically but requires deliberate action and lobbying on the part of those central to the scaling initiative. At the same time, an RS strategy would need to consider the consequences of exnovation, and thus pay attention to those who are likely to lose their business when solar panels go to scale, notably those selling kerosene or offering central mobile phone charging facilities with the help of generators. The strategy may include, for example, arrangements through which they can generate income by becoming involved in the installation or maintenance of solar systems, or in the selling of necessary appliances or spare parts.

Tailor-made communication and training: adapting networks, methods, and narratives to diverse social groups

Diverse social groups potentially affected by scaling differ regarding pre-existing knowledge and skills, cultural repertoires, media preferences, social networks, values, and interests. This has implications for the deliberation and investigation methods that may be used during the iterative co-creation process of an RS strategy. It is important that interaction with such groups takes place through modes of expression, media, and communicative settings that group members or their representatives are comfortable with (Gibson et al. 2020; Halvorsen 2001). This also holds true for the communication approaches used to support scaling among the diverse groups targeted and whose members have not been involved in the co-creation process. In line with the idea of scaling, this may commonly involve thousands or even millions of people. In view of the above, it is unlikely that the diverse social groups identified on the basis of the relevant diversity assessment can be reached and enrolled effectively through uniform narratives, training methods, intermediaries, and media strategies (Betsch et al. 2016; Leeuwis 2004). While men may be effectively mobilized by narratives about malaria control when they are communicated through radio, women may be better connected through slightly different messages and media. Consider, for example, animated brochures (Timu et al. 2024), shared through child healthcare centers or religious gatherings. An RS strategy recognizes that relevant intersectional social categories require a tailor-made approach, and the scaling partnership must therefore include those with networks and abilities to engage with diverse audiences.

Human and financial resources: mobilizing adequate expertise and investment

The development and implementation of RS strategies require the effective mobilization and/or generation of various forms of expertise as well as resources to implement the scaling strategy. Some knowledge and skills are likely to be relevant in all scaling initiatives and contexts: for example, theoretical knowledge on social differentiation, methodological expertise in facilitating stakeholder and public participation as well as deliberative processes within scaling initiatives, systems thinking to understand innovation bundles and bottlenecks, and communicative skills to address diverse audiences. These generic competences need to be combined with intimate practical insights in various dimensions of the scaling context, which can often be provided by prospective users from oft-excluded categories or by intersectional groups prone to face negative consequences of scaling. Thus, RS requires bringing together people with different disciplinary, practical, and experiential backgrounds.

Moreover, the required expertise depends on the specific nature of the core innovation and the components of the innovation packages to be scaled. This expertise could comprise knowledge on or experiences of consequences that scaling of the core innovation has had in similar contexts (if available) and investigative competences for the generation of additional insights when gaps in understanding (e.g. on relevant diversity in a specific context) arise. Thus, various forms of research can play a useful role during strategy development processes, including research on the psychological and socio-political factors that may influence adoption and space for innovation (Badstue et al. 2018; Leeuwis and Aarts 2021; Petesch et al. 2018), relevant intersectionality (Crenshaw 2005; Rietveld, van der Burg, and Groot 2020), innovation and scaling readiness (Sartas et al. 2020), and communication network analysis (Valente and Fosados 2006).

In addition, an RS strategy requires sufficient resources to develop and implement the various building blocks of a scaling strategy. Especially the development and roll-out of viable innovation packages and corresponding tailor-made communication and training can be a costly affair. Mobilizing economic expertise to assess whether or not innovation packages are economically viable and sustainable is therefore relevant to RS as well. At the level of organizations dedicated to the scaling of innovations, it is

important to monitor which innovations require more or less resources to develop and implement an RS strategy. Through 'innovation portfolio management' (Schut et al. 2024), resources can be distributed in an effective and responsible manner. If sufficient human and financial resources cannot be obtained, those involved in a scaling initiative may have to conclude that the core innovation cannot be scaled responsibly, that they need to stop or redirect activities, and/or that they should adjust their scaling ambition.

A non-linear, power-sensitive process and its conditions

The building blocks presented here are a set of co-creation and investigation practices for the development, implementation, and adaptation of RS strategies. The development and implementation of scaling strategies is never a linear process of moving from a scaling objective to the other building blocks. Instead, deliberation on each additional building block is likely to re-open discussions on what was earlier agreed upon (Leeuwis 2004; Sartas et al. 2020), as choices pertaining to one building block can have major implications for others. For instance, the intended scaling context preordains the scope of the diversity assessment, which, in turn, may spark reflections on widening the scaling context. Eventually, an RS strategy requires coherence and mutual adjustment among building blocks. Thus, the development, implementation, and adaptation of scaling strategies can be seen as a cyclical process (Figure 1). Scaling strategy development thus extends beyond the moment of initial agreement on a coherent strategy. New insights are likely to emerge from experiences obtained during the actual implementation, while particular conditions of the scaling context may change in ways unforeseen. Under changing circumstances, other 'building blocks' than the ones discussed here may become relevant.

The proposed iterative adaptation of RS strategies through time requires a willingness to 'open up,' that is a readiness to reconsider choices and decisions regarding building blocks on which some degree of closure had emerged at an earlier stage. As Stirling argues, such 'opening up' may be difficult to achieve in the context of path dependencies and prevailing power configurations that work to enforce or maintain particular forms of closure (Stirling 2008, 2014). In fact, one of the toughest tasks in developing, implementing, and adjusting an RS strategy is to deal with the power dynamics within and across the different building blocks and challenge it. Research on RI in diverse environments, but especially in those dominated by competition, strong financial or political interests, and incumbent actors (Alday et al. 2025), has shown that efforts promoting responsibility often become coopted, or even impossible, due to the politics pervading these environments and RI practices (Felt et al. 2023; van Oudheusden 2014). Similarly, narrow issue framings can be expected to bypass inclusive participation in defining legitimate scaling objectives (cf. Ludwig et al. 2021). We also recognize the risk of diversity assessment to become reduced to box-ticking exercises without practical impacts (cf. Egeland, Forsberg, and Maximova-Mentzoni 2019; Vermaas, Ammon, and Mehnert 2024), and we acknowledge that economic incentives may crowd out socio-ethical concerns in identifying scaling readiness levels (cf. Blok and Lemmens 2015). After all, the views and values of influential scaling partners, such as sponsors and the private sector, are likely to have a large influence on what is considered 'responsible' in a particular context.

In view of such dynamics, we consider it as the main task of scaling experts with a social science background to facilitate processes that open up decision-making in relation to the different building blocks for scaling strategy development (cf. Smolka et al. 2026). At the same time, we recommend the use of specific methods to facilitate a democratic deliberation process, in which temporary closure can be reached in a democratic, power-sensitive manner. An example of such a method is the Dynamic Learning Agenda (van Mierlo et al. 2010), which can encourage those involved in scaling efforts to translate scaling objectives into concrete actions while supporting regular group reflection on these objectives and actions.

First studies deploying RS methods in a power-sensitive manner indicate that they can contribute to the development of strategies that advance stakeholder engagement, decision-making regarding innovation packages, and socially equitable outcomes (Damtew et al. 2023; McGuire et al. 2024b). Despite such positive results, Damtew et al. acknowledge that the effective implementation of such methods is contingent on their institutional embedding, alignment with incentive structures, and the mindsets of scaling partners. A variety of scaling partners – including technoscientific practitioners, scaling experts with diverse backgrounds, various stakeholders, and change agents – are involved in performing RS. To do so, specific facilitating conditions and sources of legitimacy for their roles and activities need to be in place. Facilitating conditions and

sources of legitimacy for RS are presumably similar to those identified in literature on the institutionalization of RI (e.g. Alday et al. 2025; Marlussen, Virkkala, and Mäenpää 2025; Owen, Pansera, and Macnaghten 2021a). RS may be more likely to be viewed as doable and legitimate when it is a funding requirement, when it is supported by leadership and peers, and when there is general institutional commitment partly manifested in the provision of financial and temporal resources (cf. Pansera et al. 2020). In business contexts, policy and legal instruments may provide additional incentives and legitimacy for RS (cf. Ivanova et al. 2023). While legitimacy also depends on the inclusion of marginalized voices in deliberations on whether and how to perform RS, an in-depth discussion of institutional constructs and mechanisms of representation and delegation goes beyond the scope of this article.

Overall, RS depends on a wider culture shift, which values process over speed, outcome over scale, and inclusion over productivity. In support of such a shift, each RS initiative – however small or seemingly insignificant – makes a relevant contribution. Moreover, the emerging RS community can learn lessons from the RI experience of promoting such a shift at the individual, organizational, and policy level, for instance through practices of productive engagement with power differentials by performing 'recursive reflexivity' (Conley and York 2020), refusal (Lysen and Wyatt 2024), and diverse modes of critique (Smolka, Doezema, and von Schomberg 2024a). If such practices accompany the development and application of an RS strategy, we are confident that scaling can be done differently.

RS as part of RI: contributions and outlook

RI researchers have emphasized that decisions steering innovations are made in the upstream and midstream and have developed a range of approaches and methods for their responsible governance. Such emphasis, however, has been negligent of the downstream, where decision-making revolves around the scaling of innovations. Scaling often generates social injustices and negative environmental impacts, especially if scaling partners and practices pay little attention to accompanying social and institutional changes, marginalized user groups, and exploitative dynamics in global value chains. Drawing on scaling literature in the field of international agricultural development, this article introduces the concept of RS to denote practices that apply anticipation, inclusion, reflexivity, and responsiveness to the implementation and spread of innovations. To perform RS, we argue that scaling initiatives should engage in a non-linear, dynamic process of iteratively developing, implementing, and adapting diversified RS strategies. This involves ongoing deliberation and investigation for (re-)forming and (re-)ordering a set of seven building blocks in view of emerging insights and changing circumstances.

The focus on downstream processes of scaling, however, should not draw attention away from the upstream and midstream of science, technology, and innovation. In deploying the scaling metaphor with an emphasis on its complex, non-linear flow dynamics, RS emphasizes the iterative engagement with science policy, research and development, and scaling contexts (Ewell, Smolka, and Leeuwis 2026; McGuire et al. 2024b; Woltering 2024). At the same time, it may only be possible to fully assess societal consequences when the 'interpretative flexibility' (Pinch and Bijker 1987, 40) of a new technology, product, or service has stabilized and when its packaging, rather than its design, shape these consequences in considerable ways. For this reason, decisions regarding the scaling of innovations are an important but often overlooked leverage point for governance, especially in the light of the increasing popularity of scaling in policy, media, and industry discourses (Pfotenhauer et al. 2022). This also explains why, in our view, RS should be become a part of RI and why it deserves more attention than we currently witness.

This article further contributes to three branches of RI literature, in which the scaling of innovations was identified as an important topic of investigation that has still received little attention: RI in industry, innovation ecosystems, and the Global South. In introducing RS, we expand the empirical focus on RI research in industry beyond entrepreneurs and businesses and include actors and organizations all along the value chain. This widening in focus enables researchers to pay attention to 'networked responsibility' (Ceicyte and Petraite 2018; Timmermans et al. 2017) and distributed responsibility (cf. Politi and Grinbaum 2020) across diverse value chain actors and organizations participating in scaling. These actors and organizations may share responsibilities and their responsibilities may be interdependent, but they may not have equal responsibility and agency. In RS, responsibilities remain an ongoing issue of deliberation and investigation as part of an iterative strategy development, implementation, and

adaptation process, in which different parties make and continuously remake formal and informal agreements with regard to how they align their activities, mobilize and share resources, and pursue common as well as individual objectives and interests. Empirical research could yield broader insights into the dynamic formation of responsibility relations, and the role that power and politics play in pre-conditioning these relations, as well as the spatial nature and distribution of inclusive, anticipatory, reflexive, and responsive practices.

Moreover, we suggest advancing theory development for RI in innovation ecosystems with concepts from scaling literature in the field of international agricultural development. The ecosystem perspective in RI emphasizes that societal impacts of new and emerging science and technology need to be studied and steered within a socio-technical system, rather than within a circumscribed laboratory, business, or technoscientific organization. This perspective can be enriched by approaches to study and govern diverse innovation packages, one of the seven building blocks of RS strategies. As a concept, RS highlights that 'responsible innovation ecosystem governance' (Smolka and Böschen 2023) needs to engage with and stimulate reflexive capacity building within technical, organizational, and social contexts simultaneously, in particular if the ecosystem is supposed to support innovations in going to scale. Future research could further explore concepts adjacent to innovation packages, such as 'baskets of options' (Ronner et al. 2021) and 'socio-technical innovation bundles' (Barrett et al. 2022), to further stimulate theoretical reflection on the dynamics within and the governance of innovation ecosystems.

One such reflection may connect to the relation between diffusion and scaling. In their recent plea to reimagine diffusion, Robinson, Borrás, and Boon (2025) treat the two terms as synonyms. When compared to the concept of diffusion, however, we feel that, as a term, 'scaling' somewhat better expresses the multiple scales involved in innovation ecosystems. Being a gerund, 'scaling' furthermore indicates its intentional nature. Rather than involving an autonomous self-organized process, scaling commonly amounts to a deliberate professional activity through which actors strategize and intervene at multiple points in a system to enable its transformation. Linguistically and historically, the notion of 'diffusion' is tied to the relatively autonomous spreading of something specific in a given environment, which is somewhat misleading when recognizing the importance of multiple innovation packages that are strategically tuned to diverse contexts and socially differentiated categories of users and non-users, and which are geared to changing systemic frameworks and conditions.

Although we consider 'scaling' as a more appropriate term in a linguistic and performative sense, it has an inherent connotation of growth and benefits. This connotation is also inherent in the language of innovation, which is why de Saille et al. (2020) call for complementing RI with 'responsible stagnation.' Responsible stagnation implies questions as to how much growth is desirable, which possibilities of steady-state economics exist, and how to eliminate practices, products, and services that harm people and planet. In answering these questions from an RS perspective, it is important to consider the financial losses, emotional pain, and other negative effects (Bogner et al. 2024; Lonkila et al. 2024; Rinscheid et al. 2021) that some experience in the phase-out of existing technologies, products, or services. RS also implies thinking proactively about exnovation or, as it was dubbed by Wigboldus (2018), 'scaling down' (8). Therefore, the further development of RS as a concept and set of practices needs to go hand-in-hand with more elaboration on 'responsible downscaling' in future research. Such research should also investigate how changes in values, norms, and beliefs – what has been called 'scaling deep' (Lam et al. 2020, 2) – can be supported by scaling initiatives to challenge growth-oriented mindsets, even in competitive environments like innovation ecosystems (Alday et al. 2025).

RS also opens up novel perspectives for RI research in Global South contexts. It raises awareness and stimulates reflexivity about the global injustices that tend to be reproduced and exacerbated in and through scaling. To attend to such global injustices, relevant diversity assessments and scaling partnerships with those affected by the scaling of innovations are crucial. The methods attached to these building blocks help innovation teams anticipate and understand potential negative impacts on marginalized and historically disadvantaged groups in a collaborative process of scaling strategy development, implementation, and adaptation. These methods, however, were developed and tested in donor-driven applied research for agricultural development, often within a mindset of performing RS *for* Global South contexts. Future research could reverse this dynamic by ensuring that the development or tailoring of RS methods is *led by* Global South researchers and stakeholders within agricultural extension, as well as other sectors. Such research could open up possibilities for local models of innovation and scaling that offer alternatives to hegemonic scaling models and inform the 'transduction' (Doezema et al.

2019) of RS through reconfigurations of scaling strategies in line with local epistemologies, practices, and ethics.

We conclude with a note on opportunities for incorporating RS in RI. According to Pfotenhauer et al. (2022), the application of RI and adjacent governance approaches to scaling would require 'differentiating better how such instruments can be applied at different scales, and, more importantly, how they can help us to problematize the injunction to scale things up' (23). As (digital) innovations can quickly reach billions of users, one may wonder how public engagement activities could be scaled up. However, simplistic understandings of 'scaling up' could imply the problematic proliferation of standardized toolkits and templates of governance and participation that reconfigure local issues and contexts, so that they are fit for the tool (Voß and Amelung 2016). In our view, the proliferation of toolkits and templates is just one of many ways in which we could think about the scaling of RS. After all, the above quote by Pfotenhauer et al. (2022) invites us to turn RS back on itself, applying the building blocks developed here to the practices of those engaged in RS. Such a 'recursive' engagement with RS (cf. Conley and York 2020) means pluralizing ways of scaling RS approaches, attuning engagement activities to different scales, and paying attention to variations in worldviews, values, and issue framings. Reflexive engagement with underpinning power dynamics is crucial in tailoring RS methods to small scales (e.g. focus groups, reflexive dialogues, co-design methods) and big scales (e.g. standardization, policymaking, and mass communication), and for exchange, coordination, and alignment between multiple scales (e.g. multi-stakeholder workshops).

This 'multi-scalar approach' (Wiarda and Doorn 2023) cannot be performed by small groups of actors but requires the involvement of multiple actors in different roles and at different systems levels. These actors need to be reflexively aware of their positions, recognize themselves as capable of contributing to RS, and 'think both locally and globally' (1). To develop this mindset, we propose to create shared platforms in the form of global observatories, similar to those established for gene editing (Jasanoff and Hurlbut 2018) and artificial intelligence (Domínguez Hernández, Briggs, and Mahomed 2024). Observatories would consist of international networks of researchers, businesses, and other organizations that gather information, bring together diverse perspectives on scaling, and advocate different approaches to scaling, as well as various practices of scaling. An example of an emerging observatory with a focus on scaling is the Scaling Coalition for agrifood innovations (Buono et al. 2025). An observatory for RI would also allow for comparative research on how RS practices evolve within and across different sectors, shaped by diverging contextual conditions.

In a multi-scalar approach, it is important continuously to question the purpose and form of scaling. The hegemonic linear model of scaling drives the production of 'more of the same' at a high speed and in high volumes. However, as we emphasize here, scaling can be performed otherwise – for instance, by developing and scaling innovation packages in a more differentiated manner while paying simultaneous attention to scaling deep and scaling down. To challenge the hegemony of market imperatives and assumptions of technological determinism, RI researchers who move downstream should thus make efforts to unsettle and open up how scaling is framed, envisioned, and approached.

Notes

1. Although the stream metaphor has been criticized for embracing residues of the linear model, it is commonly used in RI literature (Fisher, Mahajan, and Mitcham 2006; Krabbenborg and Mulder 2015; Rogers-Hayden and Pidgeon 2007).
2. Although scaling is discussed and critiqued across sectors, we rely more strongly on literature from international agricultural development because it has informed our work on RS in particular, as we will show below.
3. RS resembles 'responsible adoption' coined by Reichelt and Nettle (2023).
4. This community has emerged within and in relation to the Consultative Group on International Agricultural Research (CGIAR), a global partnership that unites international organizations involved in investigating food security and meets regularly at 'Scaling Weeks' (Ewell et al. 2025).
5. Literature on just transitions explores different social justice dimensions of large-scale transformation processes, in particular in relation to high emitting industries (Stark, Gale, and Murphy-Gregory 2023; Tschersich and Kok 2022).
6. https://dictionary.cambridge.org/dictionary/english/strategy.
7. This contrasts with regularly observed discourses (e.g. around Silicon Valley), which make it seem as though scaling was an end in itself rather than a means to achieve societal objectives (Pfotenhauer et al. 2022).

8. In some cases, scaling is initiated by several parties rather than by one party that takes the lead, for example in transdisciplinary consortia working toward healthy eating habits (Bottorff et al. 2021). In such cases the distinction between primary and complementary scaling objectives may be less useful, but the legitimacy of scaling objectives is still a relevant requirement for responsible scaling.

Author contributions (CRediT)

Cees Leeuwis*: conceptualization; writing – original draft; writing – review & editing; funding acquisition; Mareike Smolka*: conceptualization; writing – original draft; writing – review & editing; Hanna Ewell: writing – review & editing; funding acquisition; Erin McGuire: conceptualization; writing – review & editing; Esther Kihoro: writing – review & editing; Philipp Neudert: writing – review & editing; Ebenezer Ngissah: writing – review & editing; Samuel Mugambi: writing – review & editing; Marc Schut: writing – review & editing; funding acquisition; Laurens Klerkx: conceptualization; writing – review & editing; funding acquisition; *Cees Leeuwis and Mareike Smolka share first authorship.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The preparation of this article was supported by the CGIAR Scaling for Impact Program and the Gates Foundation. We thank all funders who supported this work through their contributions to the CGIAR Trust Fund (http://www.cgiar.org/funders). In addition, funding was received from the Chilean National Agency for Research and Development [ANID CA2FST CIN250015].

Notes on contributors

Prof. Cees Leeuwis is professor of collaborative research, communication and change at Wageningen University in the Netherlands. He studies processes of socio-technical innovation, scaling, and transformation in networks, collaborations between different disciplines, research for development policy, and innovation support systems. He also investigates the role of innovation platforms, science communication, extension, and brokers therein. He is active in various societal domains, including sustainable agriculture, natural resources management, poverty-related diseases and inclusive value chains. Previously, Cees Leeuwis was professor and chair of the Communication & Innovation Studies group (2002–2012) and professor and chair of the Knowledge, Technology & Innovation group (2012–2021) at Wageningen University.

Dr. Mareike Smolka is assistant professor in the Knowledge, Technology & Innovation group at Wageningen University in the Netherlands and a research fellow at the Human Technology Center of RWTH Aachen University in Germany. She has a background in responsible innovation, science and technology studies, empirical ethics, critical innovation studies, and transition studies. She engages in inter- and transdisciplinary projects to study and enhance the alignment between societal considerations and science, technology, and innovation. In her current projects, she explores systemic approaches to the responsible governance of innovation ecosystems, paying particular attention to anticipation and reflexivity in hardware and software development of artificial intelligence.

Hanna Ewell (MSc) is a research specialist with the Alliance of Biodiversity International and the International Center for Tropical Agriculture (CIAT), based in Nairobi, Kenya, and PhD candidate in the Knowledge, Technology & Innovation group at Wageningen University. She currently works on responsible scaling within the Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) program, and through transdisciplinary collaboration, supports teams in considering the complexity of scaling. With a background in sustainable development and environmental management and a focus on gender and social inclusion, she is interested in systemic approaches to responsibly transform agri-food systems.

Dr. Erin McGuire has been leading inclusive agricultural innovation at University of California, Davis for 15 years and is the founder of Responsible Innovations and co-developer of the GenderUp framework. She specializes in responsible and equitable approaches to agricultural innovation and scaling, with a strong emphasis on equity, intersectionality, and locally led systems change. Her work integrates perspectives from feminist approaches, innovation studies, and food systems research to advance socially responsive and impactful innovation pathways. Erin McGuire has led inter- and transdisciplinary collaborations with multilateral organizations, universities, and global research partners to embed responsibility and inclusivity into agricultural research for development. Through GenderUp, she has trained more than 150 facilitators worldwide to anticipate social consequences, address systemic inequities, and design scaling

strategies that create transformative impact. In her current projects, she explores systemic approaches to innovation governance, focusing on how diagnostics, capacity strengthening, and co-creation can support more effective and equitable food and agricultural systems.

Dr. Esther Kihoro is a researcher working on the science and practice of scaling at CGIAR in collaboration with Wageningen University. She focuses on responsible scaling for transformative change, supporting innovation teams to navigate scaling pathways, and embed learning in agri-food systems transformation. With a background in gender, climate change, and rural development, she brings a systems-oriented and practice-based lens to scaling. She is an executive guest editor for the *Agricultural Systems* special issue on responsible scaling for transformative agri-food systems.

Philipp Neudert (M.A.) works as a research associate at the Human Technology Center of RWTH Aachen University in Germany. He has a background in science and technology studies, philosophy, and economics. He works in an inter- and transdisciplinary research project on 'neuromorphic' computing technology (NeuroSys). His dissertation focuses on the emerging innovation ecosystem of NeuroSys and the role played by futures for its governance. As co-PI of the field of activity on collaborative innovation at the Human Technology Center, he co-coordinates several projects studying and engaging with innovation dynamics in innovation ecosystems and other transdisciplinary contexts.

Ebenezer Ngissah (MSc) is a PhD candidate with the Knowledge, Technology & Innovation group at Wageningen University and a research fellow at the International Livestock Research Institute (ILRI). His expertise lies in digital agricultural tools and their application in rural development contexts. His current research explores the role of digital technologies, particularly artificial intelligence, in fostering intelligence for responsible innovation and enabling the scaling of agricultural solutions.

Samuel Mugambi (MSc) is a PhD candidate with the Knowledge, Technology & Innovation group at Wageningen University. He has experience in international agricultural research in developing countries and is interested in the dynamics of supply and demand for innovations. His current research examines the role of organizational and institutional dynamics in shaping innovation processes and outcomes.

Dr. Marc Schut is a senior innovation portfolio management advisor and scientist working with Wageningen University and CGIAR, based in Nairobi, Kenya. Marc is passionate about understanding and nurturing innovation and scaling processes for positive societal impact. He led multi-cultural and interdisciplinary research and innovation teams and managed comprehensive donor-funded programs. Marc Schut published over 50 scientific publications, and has over 15 years of experience in working with partners in low- and middle-income countries.

Prof. Laurens Klerkx is professor of agrifood innovation and transition at the Department of Agricultural Economics at the University of Talca in Chile and visiting professor at Wageningen University in the Netherlands. He also serves as deputy director and principal investigator at the Center for Advancing Agri-Food Systems Transformation (CA2FST) in Chile. He is an expert in the field of (agricultural) innovation studies, doing social science research on various topics, such as institutional change, multi-stakeholder networks, transdisciplinary science, research and innovation policy, and innovation ecosystems. Laurens Klerkx has (co-)authored more than 180 articles in international peer-reviewed journals, which draw on his research in The Netherlands, England, New Zealand, Vietnam, Tanzania, Kenya, Ghana, Chile, Mexico, and other countries.

ORCID

Cees Leeuwis http://orcid.org/0000-0003-1146-9413
Mareike Smolka http://orcid.org/0000-0002-0343-0888
Hanna Ewell http://orcid.org/0009-0003-0304-3874
Erin McGuire http://orcid.org/0000-0001-7775-4108
Esther Kihoro http://orcid.org/0000-0002-0956-5134
Philipp Neudert http://orcid.org/0000-0001-8005-636X
Ebenezer Ngissah http://orcid.org/0009-0009-1351-9868
Samuel Mugambi http://orcid.org/0000-0001-7088-4479
Marc Schut http://orcid.org/0000-0002-3361-4581
Laurens Klerkx http://orcid.org/0000-0002-1664-886X

References

Agar, Jon. 2013. *Constant Touch: A Global History of the Mobile Phone*. London: Icon Books.

Alday, Edurne Iñigo, Keren Naa Abeka Arthur, Vincent Blok, Jilde Garst, Richard Owen, and Bernd Carsten Stahl. 2025. "Embedding RRI in Competitive Environments: Stakeholders, Structures, and Systemic Tensions." *Journal of Responsible Innovation* 12 (1): 2529047. https://doi.org/10.1080/23299460.2025.2529047.

Altieri, Miguel A., and Clara I. Nicholls. 2012. "Agroecology Scaling up for Food Sovereignty and Resiliency." In *Sustainable Agriculture Reviews: Volume 11*, edited by Eric Lichtfouse, 1–29. Dordrecht: Springer Netherlands.

Anantharajah, Kirsty. 2024. "Loving Technologies? Beyond Climate Finance's Logics of Scalability in Infrastructures in Fiji." *Science, Technology & Human Values* 50 (5): 962–988. https://doi.org/10.1177/01622439241276277.

Anderson-Samways, Bill, Shaun Ee, Joe O'Brien, Marie Buhl, and Zoe Williams. 2024. "Responsible Scaling: Comparing Government Guidance and Company Policy. Institute for AI Policy and Strategy." Accessed on August 1, 2025. https://www.iaps.ai/research/responsible-scaling.

Andersson, Jens A., and Ken E. Giller. 2012. "On Heretics and God's Blanket Salesmen: Contested Claims for Conservation Agriculture and the Politics of Its Promotion in African Smallholder Farming." In *Contested Agronomy: Agricultural Research in a Changing World*, edited by James Sumberg, and John Thompson, 22–46. London: Routledge.

Badstue, Lone B., Diana E. Lopez, Anya Umantseva, George Williams, Marlène Elias, Cathy R. Farnworth, et al. 2018. "What Drives Capacity to Innovate? Insights from Women and men Small-Scale Farmers in Africa, Asia, and Latin America." *Journal of Gender, Agriculture and Food Security* 3 (1): 54–81.

Balbi, Gabriele, and Christiane Berth. 2019. "Towards a Telephonic History of Technology." *History and Technology* 35 (2): 105–114. https://doi.org/10.1080/07341512.2019.1652959.

Barrett, Christopher B., Tim Benton, Jessica Fanzo, Mario Herrero, Rebecca J. Nelson, Elizabeth Bageant, et al. 2022. *Socio-Technical Innovation Bundles for Agri-Food Systems*. Cham: Palgrave Macmillan.

Bartholomew, Eldredge, L. Kay, Christine M. Markham, Robert A. C. Ruiter, María E. Fernández, Guy S. Parcel, and Gerjo Kok (2016/2017). *Planning Health Promotion Programs: An Intervention Mapping Approach. 4th Ed.* San Francisco: Jossey-Bass Inc.

Baurzhan, Saule, and Glenn P. Jenkins. 2016. "Off-grid Solar PV: Is It an Affordable or Appropriate Solution for Rural Electrification in Sub-saharan African Countries?" *Renewable and Sustainable Energy Reviews* 60:1405–1418. https://doi.org/10.1016/j.rser.2016.03.016.

Benjamin, Ruha. 2019. *Race after Technology*. Cambridge: Polity Press.

Betsch, Cornelia, Robert Böhm, Collins O. Airhihenbuwa, Robb Butler, Gretchen B. Chapman, Niels Haase, et al. 2016. "Improving Medical Decision Making and Health Promotion through Culture-Sensitive Health Communication: An Agenda for Science and Practice." *Medical Decision Making: An International Journal of the Society for Medical Decision Making* 36 (7): 811–833. https://doi.org/10.1177/0272989X15600434.

Biggi, Gianluca, and Elisa Giuliani. 2021. "The Noxious Consequences of Innovation: What Do We Know?" *Industry and Innovation* 28 (1): 19–41. https://doi.org/10.1080/13662716.2020.1726729.

Bless, Anja, Federico Davila, and Roel Plant. 2023. "A Genealogy of Sustainable Agriculture Narratives: Implications for the Transformative Potential of Regenerative Agriculture." *Agriculture and Human Values* 40:1379–1397. https://doi.org/10.1007/s10460-023-10444-4.

Blok, Vincent, and Pieter Lemmens. 2015. "The Emerging Concept of Responsible Innovation. Three Reasons Why It Is Questionable and Calls for a Radical Transformation of the Concept of Innovation." In *Responsible Innovation 2*, edited by Bert-Jaap Koops, Ilse Oosterlaken, Henny Romijn, Tsjalling Swierstra, and Jeroen van den Hoven, 19–35. Cham: Springer Nature.

Bogner, Kristina, Barbara Kump, Mayte Beekman, and Julia Wittmayer. 2024. "Coping with Transition Pain: An Emotions Perspective on Phase-Outs in Sustainability Transitions." *Environmental Innovation and Societal Transitions* 50:100806. https://doi.org/10.1016/j.eist.2023.100806.

Boon, Wouter P. C. 2025. Verantwoord opschalen van innovaties voor maatschappelijke uitdagingen. [Responsible scaling of innovations for societal challenges]. Inaugural lecture, University Utrecht.

Borlaug, Norman E. 2000. "Ending World Hunger. The Promise of Biotechnology and the Threat of Antiscience Zealotry." *Plant Physiology* 124 (2): 487–490. https://doi.org/10.1104/pp.124.2.487.

Bottorff, Joan L., Anne Huisken, Michele Hopkins, and Lynnelle Friesen. 2021. "Scaling up a Community-led Health Promotion Initiative: Lessons Learned and Promising Practices from the Healthy Weights for Children Project." *Evaluation and Program Planning* 87:101943. https://doi.org/10.1016/j.evalprogplan.2021.101943.

Bourhis, John. 2018. "Narrative Literature Review." In *The SAGE Encyclopedia of Communication Research Methods*, edited by Mile Allen, 1076–1077. New York: SAGE Publications Inc. https://doi.org/10.4135/9781483381411.n370.

Bouwman, Tristin I., Jens A. Anderson, and Ken E. Giller. 2021. "Herbicide Induced Hunger? Conservation Agriculture, Ganyu Labour and Rural Poverty in Central Malawi." *Journal of Development Studies* 57 (2): 244–263. https://doi.org/10.1080/00220388.2020.1786062.

Bögel, Paula Maria, Karoline Augenstein, Meike Levin-Keitel, and Paul Upham. 2022. "An Interdisciplinary Perspective on Scaling in Transitions: Connecting Actors and Space." *Environmental Innovation and Societal Transitions* 42:170–183. https://doi.org/10.1016/j.eist.2021.12.009.

Bruce, Ann, and Donald Bruce. 2019. "Genome Editing and Responsible Innovation, Can They Be Reconciled?" *Journal of Agricultural and Environmental Ethics* 32:769–788. https://doi.org/10.1007/s10806-019-09789-w.

Bruland, Kristine, and David C. Mowery. 2014. "Technology and the Spread of Capitalism." In *The Cambridge History of Capitalism. Volume II*, edited by Larry Neal, and Jeffrey G. Williamson, 82–126. Cambridge: Cambridge University Press. https://doi.org/10.1017/CHO9781139095105.004.

Bucic, Tania, and Gina Colarelli O'Connor. 2024. "Avoiding Harm in Technology Innovation." *MIT Sloan Management Review* 66 (1): 76–81. https://sloanreview.mit.edu/article/avoiding-harm-in-technology-innovation/.

Buono, Nicoletta, Iddo Dorr, Marc Schut, Agnes Schneidt, and Till Rockenbauch. 2025. *Scaling Coalition: Executive Progress Summary*. Nairobi: International Livestock Research Institute.
Buur, Jacob, and Ben Matthews. 2008. "Participatory Innovation." *International Journal of Innovation Management* 12 (3): 255–273. https://doi.org/10.1142/S1363919608001996.
Capurro, Gabriela, Holly Longstaff, Patricia Hanney, and David M. Secko. 2015. "Responsible Innovation: An Approach for Extracting Public Values concerning Advanced Biofuels." *Journal of Responsible Innovation* 2 (3): 246–265. https://doi.org/10.1080/23299460.2015.1091252.
Ceicyte, Jolita, and Monika Petraite. 2018. "Networked Responsibility Approach for Responsible Innovation: Perspective of the Firm." *Sustainability* 10 (6): 1720. https://doi.org/10.3390/su10061720.
Checkland, Peter B. 1981. *Systems Thinking, Systems Practice*. Chichester: Wiley & Sons.
Chilvers, Jason, and Matthew Kearnes. 2016. *Remaking Participation. Science, Environment and Emergent Publics*. New York: Routledge.
Chun, Wendy Hui Kyong. 2024. *Discriminating Data. Correlation, Neighborhoods, and the New Politics of Recognition*. Cambridge: The MIT Press.
Collingridge, David. 1980. *The Social Control of Technology*. Milton Keynes: Open University Press.
Conley, Shannon, and Emily York. 2020. "Public Engagement in Contested Political Contexts: Reflections on the Role of Recursive Reflexivity in Responsible Innovation." *Journal of Responsible Innovation* 7 (sup 1): 1–12. https://doi.org/10.1080/23299460.2020.1848335.
Crenshaw, Kimberle. 2005. "Mapping the Margins: Intersectionality, Identity Politics, and Violence against Women of Color." *Stanford Law Review* 43 (6): 1241–1299.
Criado-Perez, Caroline. 2019. *Invisible Women: Data Bias in a World Designed for Men*. New York: Vintage Publishing.
Damtew, Elias, Boru Douthwaite, Marc Schut, Murat Sartas, and Cees Leeuwis. 2023. "Improving Scaling Performance in Research for Development: Learning from a Realist Evaluation of the Scaling Readiness Approach." *The European Journal of Development Research* 35:1392–1418. https://doi.org/10.1057/s41287-023-00586-w.
David, Martin, and Matthias Gross. 2019. "Futurizing Politics and the Sustainability of Real-World Experiments: What Role for Innovation and Exnovation in the German Energy Transition?" *Sustainability Science* 14 (4): 991–1000. https://doi.org/10.1007/s11625-019-00681-0.
Dawson, Neil, Adrian Martin, and Thomas Sikor. 2016. "Green Revolution in sub-saharan Africa: Implications of Imposed Innovation for the Wellbeing of Rural Smallholders." *World Development* 78:204–218. https://doi.org/10.1016/j.worlddev.2015.10.008.
de Laet, Marianne, and Annemarie Mol. 2000. "The Zimbabwe Bush Pump: Mechanics of a Fluid Technology." *Social Studies of Science* 30 (2): 225–263. https://www.jstor.org/stable/285835.
de Roo, Nina, Conny Almekinders, Cees Leeuwis, and Tewodros Tefera. 2019. "Scaling Modern Technology or Scaling Exclusion? The Socio-Political Dynamics of Accessing in Malt Barley Innovation in two Highland Communities in Southern Ethiopia." *Agricultural Systems* 174:52–62. https://doi.org/10.1016/j.agsy.2019.04.004.
de Saille, Stevienna, Fabien Medvecky, Michiel van Oudheusden, Kevin Albertson, Effie Amanatidou, Timothy Birabi, and Mario Pansera. 2020. *Responsibility beyond Growth. A Case for Responsible Stagnation*. Bristol: Bristol University Press.
Dijk, Marc, Joop de Kraker, and Anique Hommels. 2018. "Anticipating Constraints on Upscaling from Urban Innovation Experiments." *Sustainability* 10 (8): 2796. https://doi.org/10.3390/su10082796.
Doezema, Tess, David Ludwig, Phil Macnaghten, Clare Shelley-Egan, and Ellen-Marie Forsberg. 2019. "Translation, Transduction, and Transformation: Expanding Practices of Responsibility across Borders." *Journal of Responsible Innovation* 6 (3): 323–331. https://doi.org/10.1080/23299460.2019.1653155.
Domínguez Hernández, Andrés, Morgan Briggs, and Sabeehah Mahomed. 2024. "Why We Need a Global Approach to the Governance of AI." The Alan Turing Institute. Accessed on March 14, 2026. https://www.turing.ac.uk/blog/why-we-need-globalapproach-governance-ai.
Domínguez Hernández, Andrés, and Richard Owen. 2024. "'We Have Opened a Can of Worms': Using Collaborative Ethnography to Advance Responsible Artificial Intelligence Innovation." *Journal of Responsible Innovation* 11 (1): 2331655. https://doi.org/10.1080/23299460.2024.2331655.
Donovan, Jason, Pieter Rutsaert, David Spielman, Kelvin M. Shikuku, and Matty Demont. 2021. "Seed Value Chain Development in the Global South: Key Issues and new Directions for Public Breeding Programs." *Outlook on Agriculture* 50 (4): 366–377. https://doi.org/10.1177/00307270211059551.
Douglas, Heather, Megan K. Halpern, and Eleanor Louson. 2024. "Engaging Publics in Science: A Practical Typology." *Journal of Responsible Innovation* 11 (1): 2419238. https://doi.org/10.1080/23299460.2024.2419238.
Edquist, Charles. 2013. *Systems of Innovation: Technologies, Institutions and Organizations*. London: Routledge.
Egeland, Cathrine, Ellen-Marie Forsberg, and Tatiana Maximova-Mentzoni. 2019. "RRI: Implementation as Learning." *Journal of Responsible Innovation* 6 (3): 375–380. https://doi.org/10.1080/23299460.2019.1603570.
Engels, Franziska, Alexander Wentland, and Sebastian M. Pfotenhauer. 2019. "Testing Future Societies? Developing a Framework for Test Beds and Living Labs as Instruments of Innovation Governance." *Research Policy* 48 (9): 103826. https://doi.org/10.1016/j.respol.2019.103826.

Ewell, Hanna, Erin McGuire, Esther Kihoro, and Susanne Bodach. 2025. "Putting the Responsible into Scaling Readiness: Integrating GenderUp with CGIAR's IPSR Process." CGIAR. Accessed on August 1, 2025. https://www.cgiar.org/news-events/news/putting-the-responsible-into-scaling-readiness-integrating-genderup-with-cgiars-ipsr-process/.

Ewell, Hanna, Mareike Smolka, and Cees Leeuwis. 2026. "Too Late for Responsibility? Dialogic Prompts for Responsible Decision-Making in Agricultural Research for Development." *Agricultural Systems* 239: 104896. https://doi.org/10.1016/j.agsy.2026.104896.

Felt, Ulrike, Susanne Öchsner, Robin Rae, and Ekaterina Osipova. 2023. "Doing Co-creation: Power and Critique in the Development of a European Health Data Infrastructure." *Journal of Responsible Innovation* 10 (1): 2235931. https://doi.org/10.1080/23299460.2023.2235931.

Fielke, Simon, Kelly Bronson, Michael Carolan, Callum Eastwood, Vaughan Higgins, Emma Jakku, et al. 2022. "A Call to Expand Disciplinary Boundaries So That Social Scientific Imagination and Practice Are Central to Quests for 'Responsible'digital Agri-Food Innovation." *Sociologia Ruralis* 62 (2): 151–161. https://doi.org/10.1111/soru.12376.

Fisher, Erik, Roop L. Mahajan, and Carl Mitcham. 2006. "Midstream Modulation of Technology: Governance from Within." *Bulletin of Science, Technology & Society* 26 (6): 485–496. https://doi.org/10.1177/0270467606295402.

Fisher, Erik, Michael O'Rourke, Robert Evans, Eric B. Kennedy, Michael E. Gorman, and Thomas P. Seager. 2015. "Mapping the Integrative Field: Taking Stock of Socio-Technical Collaborations." *Journal of Responsible Innovation* 2 (1): 39–61. https://doi.org/10.1080/23299460.2014.1001671.

Fisher, Erik, Mareike Smolka, Richard Owen, Mario Pansera, David H. Guston, Armin Grunwald, et al. 2024. "Responsible Innovation Scholarship: Normative, Empirical, Theoretical, and Engaged." *Journal of Responsible Innovation* 11 (1): 2309060. https://doi.org/10.1080/23299460.2024.2309060.

Fleck, James. 1993. "Innofusion: Feedback in the Innovation Process." In *Systems Science. Addressing Global Issues*, edited by Frank A. Stowell, Daune West, and James G. Howell, 169–174. New York: Springer.

Foxon, Timothy J. 2002. "Technological and Institutional 'lock-in' as a Barrier to Sustainable Innovation." Imperial College Centre for Policy and Technology Working Paper.

Gebreyes, Millionen, Kindu Mekonnen, Peter Thorne, Melkamu Derseh, Aberra Adie, Annet Mulema, et al. 2021. "Overcoming Constraints of Scaling: Critical and Empirical Perspectives on Agricultural Innovation Scaling." *PLoS One* 16 (5): e0251958. https://doi.org/10.1371/journal.pone.0251958.

Gibson, Kristin E., Alexa J. Lamm, Kevan W. Lamm, and Laura A. Warner. 2020. "Communicating with Diverse Audiences about Sustainable Farming: Does Rurality Matter?" *Journal of Agricultural Education* 61 (4): 165–174. https://doi.org/10.5032/jae.2020.04156.

Glover, Dominic, James Sumberg, Jens A. Andersson, and Lone Badstue. 2019. "Rethinking Technological Change in Smallholder Agriculture." *Outlook Agriculture* 48:169–180. https://doi.org/10.1177/0030727019864978.

Glückler, Johannes, and Harald Bathelt. 2017. "Institutional Context and Innovation." In *The Elgar Companion to Innovation and Knowledge Creation*, edited by Harald Bathelt, Patrick Cohendet, Sebastian Henn, and Laurent Simon, 121–137. Cheltenham: Edward Elgar Publishing.

Hall, Jeremy, Vernon Bachor, and Stelvia Matos. 2014. "Developing and Diffusing New Technologies: Strategies for Legitimization." *California Management Review* 56 (3): 98–117. https://doi.org/10.1525/cmr.2014.56.3.98.

Hall, Andrew John, and Norman Clark. 2010. "What Do Complex Adaptive Systems Look Like and What Are the Implications for Innovation Policy?" *Journal of International Development* 22 (3): 308–324. https://doi.org/10.1002/jid.1690.

Hall, Andy, and Jeroen Dijkman. 2019. *Public Agricultural Research in an Era of Transformation: The Challenge of Agri-Food System Innovation*. Canberra: CGIAR Independent Science and Partnership Council (ISPC).

Halvorsen, Kathleen E. 2001. "Assessing Public Participation Techniques for Comfort, Convenience, Satisfaction, and Deliberation." *Environmental Management* 28 (2): 179–186. https://doi.org/10.1007/s002670010216.

Hekkert, Marko P., Roald A. A. Suurs, Simona O. Negro, Stefan Kuhlmann, and Rudolf E. H. M. Smits. 2007. "Functions of Innovation Systems: A new Approach for Analysing Technological Change." *Technological Forecasting and Social Change* 74 (4): 413–432. https://doi.org/10.1016/j.techfore.2006.03.002.

Hobbs, Peter R., Ken Sayre, and Raj Gupta. 2007. "The Role of Conservation Agriculture in Sustainable Agriculture." *Philosophical Transactions of the Royal Society B: Biological Sciences* 363 (1491): 543–555. https://doi.org/10.1098/rstb.2007.2169.

Hoffman, Reid, Chris Yeh, and Bill Gates. 2018. *Blitzscaling: The Lightning-Fast Path to Building Massively Valuable Companies*. New York: Currency.

Hogan, Mél. 2015. "Data Flows and Water Woes: The Utah Data Center." *Big Data & Society* 2 (2): 2053951715592429.

Hounkonnou, Dominique, Dansou Kossou, Thomas W. Kuyper, Cees Leeuwis, E. Suzanne Nederlof, Niels Röling, et al. 2012. "An Innovation Systems Approach to Institutional Change: Smallholder Development in West Africa." *Agricultural Systems* 108:74–83. https://doi.org/10.1016/j.agsy.2012.01.007.

Hubinger, Evan. 2025. "Anthropic: Responsible Scaling Policy." *SuperIntelligence - Robotics - Safety & Alignment* 2 (1). https://doi.org/10.70777/si.v2i1.13657.

Hyötyläinen, Mika. 2022. "Labour-saving Technology and Advanced Marginality – a Study of Unemployed Workers' Experiences of Displacement in Finland." *Critical Social Policy* 42 (2): 285–305. https://doi.org/10.1177/02610183211024122.

Ivanova, Svetlana, Constanze Reichetzer, André Martinuzzi, Florian Findler, and Katharina Miko-Schefzig. 2023. "Frames, Interests, and Incentives – a Typology of Institutionalizing RRI in the Business Sector Derived from Ten Pioneering Projects." *Journal of Responsible Innovation* 10 (1): 2267736. https://doi.org/10.1080/23299460.2023.2267736.

Jacobs, Floortje, Jan Ubels, and Lennart Woltering. 2018. "The Scaling Scan – A Practical Tool to Determine the Strengths And Weaknesses of Your Scaling Ambition." Report Published by PPPlab Food & Water and International Maize and Wheat Improvement Center (CIMMYT).

Jamal, Farah, Marcello Bertotti, Theo Lorenc, and Angela Hardon. 2013. "Reviewing Conceptualisations of Community: Reflections on a Meta-narrative Approach." *Qualitative Research* 15 (3): 314–333. https://doi.org/10.1177/1468794113509262.

Jasanoff, Sheila, and J. Benjamin Hurlbut. 2018. "A Global Observatory for Gene Editing." *Nature* 555:436–437. https://doi.org/10.1038/d41586-018-03270-w.

Jiggins, Janice, and Henk de Zeeuw. 1992. "Participatory Technology Development in Practice: Process and Methods." In *Farming for the Future: An Introduction to Low-External-Input and Sustainable Agriculture*, edited by Coen Reijnties, Bertus Haverkort, and Ann Waters-Bayer, 135–162. Leusden: Macmillan.

Kapsalis, Vasileios, Carmen Maduta, Nikolaos Skandalos, Sushant Suresh Bhuvad, Delia D'Agostino, Rebecca Jing Yang, et al. 2024. "Bottom-up Energy Transition through Rooftop PV Upscaling: Remaining Issues and Emerging Upgrades towards NZEBs at Different Climatic Conditions." *Renewable and Sustainable Energy Transition* 5:10083. https://doi.org/10.1016/j.rset.2024.100083.

Kihoro, Esther, Marc Schut, Erin McGuire, Million Gebreyes, and Cees Leeuwis. 2025. "Responsible Scaling for Transformative Impact: Lessons from the Science and Practice of Responsible Scaling for Agri-Food System Transformation." *Agricultural Systems* 229:104427. https://doi.org/10.1016/j.agsy.2025.104427.

Klerkx, Laurens, Barbara van Mierlo, and Cees Leeuwis. 2012. "Evolution of Systems Approaches to Agricultural Innovation: Concepts, Analysis and Interventions." In *Farming Systems Research into the 21st Century: The New Dynamic*, edited by Ika Darnhofer, David Gibbon, and Benoît Dedieu, 457–483. Dordrecht: Springer.

Kline, Stephen J., and Nathan Rosenberg. 1986. "An Overview of Innovation." In *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, edited by Ralph Landau and Nathan Rosenberg, 275–305. Washington DC: National Academy Press.

Koelen, Maria A., and Anne W. van den Ban. 2004. *Health Education and Health Promotion*. Wageningen: Wageningen Academic Publishers.

Kostakis, Vasilis, Lucas Lemos, and Asimina Kouvara. 2024. "Another Scalability Is Possible! From Nonscalability to Cosmological Scalability." *tripleC* 22 (2): 620–629. https://doi.org/10.31269/triplec.v22i2.1535.

Krabbenborg, Lotte, and Henk A. J. Mulder. 2015. "Upstream Public Engagement in Nanotechnology: Constraints and Opportunities." *Science Communication* 37 (4): 452–484. https://doi.org/10.1177/1075547015588601.

Lam, David P. M., Berta Martín-López, Arnim Wiek, Elena M. Bennett, Niki Frantzeskaki, Andra I. Horcea-Milcu, and Daniel J. Lang. 2020. "Scaling the Impact of Sustainability Initiatives: A Typology of Amplification Processes." *Urban Transformations* 2:3. https://doi.org/10.1186/s42854-020-00007-9.

Lange, Francie, Nino Tomini, Florian Brinkmann, Dominik Kanbach, and Sascha Kraus. 2023. "Demystifying Massive and Rapid Business Scaling - an Explorative Study on Driving Factors in Digital Start-ups." *Technological Forecasting & Social Change* 196:122841. https://doi.org/10.1016/j.techfore.2023.122841.

Laurent, Brice, and Alexandre Violle. 2024. "Scaling up or Deep Scaling? Problematizing the Scalability Imperative in Technological Innovation." *Science, Technology & Human Values* 50 (2): 419–446. https://doi.org/10.1177/01622439241259411.

Leeuwis, Cees. 2004. *Communication for Rural Innovation: Rethinking Agricultural Extension*. Oxford: Blackwell Science Ltd.

Leeuwis, Cees, and Noelle Aarts. 2021. "Rethinking Adoption and Diffusion as a Collective Social Process. Towards an Interactional Perspective." In *The Innovation Revolution in Agriculture – a Roadmap to Value Creation*, edited by Hugo Camps, 95–116. Cham: Springer.

Leeuwis, Cees, Laurens Klerkx, and Marc Schut. 2018. "Reforming the Research Policy and Impact Culture in the CGIAR: Integrating Science and Systemic Capacity Development." *Global Food Security* 16:17–21. https://doi.org/10.1016/j.gfs.2017.06.002.

Lonkila, Annika, Jani P. Lukkarinen, Laura van Oers, Giuseppe Feola, and Minna Kaljonen. 2024. "Just Destabilisation? Considering Justice in the Phase-out of Peat." *Environmental Innovation and Societal Transitions* 52:100867. https://doi.org/10.1016/j.eist.2024.100867.

Low, Jan W., and Graham Thiele. 2020. "Understanding Innovation: The Development and Scaling of Orange-Fleshed Sweetpotato in Major African Food Systems." *Agricultural Systems* 179:102770. https://doi.org/10.1016/j.agsy.2019.102770.

Lubberink, Rob, Vincent Blok, Johan van Ophem, and Onno Omta. 2019. "Responsible Innovation by Social Entrepreneurs: An Exploratory Study of Values Integration in Innovations." *Journal of Responsible Innovation* 6 (2): 179–210. https://doi.org/10.1080/23299460.2019.1572374.

Ludwig, David, Vincent Blok, Marie Garnier, Phil Macnaghten, and Auke Pols. 2021. "What's Wrong with Global Challenges?" *Journal of Responsible Innovation* 9 (1): 6–27. https://doi.org/10.1080/23299460.2021.2000130.

Lukkien, Dirk R. M., Henk Herman Nap, Alexander Peine, Mirella M. N. Minkman, Ellen H. M. Moors, and Wouter P. C. Boon. 2025. "Responsible Scaling of Artificial Intelligence in Healthcare: Standardization Meets Customization." *Ethics and Information Technology* 27 (3): 34. https://doi.org/10.1007/s10676-025-09842-5.

Lundvall, Bengt-Åke. 2010. *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Anthem Press.

Lysen, Flora, and Sally Wyatt. 2024. "Refusing Participation: Hesitations about Designing Responsible Patient Engagement with Artificial Intelligence in Healthcare." *Journal of Responsible Innovation* 11 (1): 2300161. https://doi.org/10.1080/23299460.2023.2300161.

Macnaghten, Phil. 2016. "Responsible Innovation and the Reshaping of Existing Technological Trajectories: The Hard Case of Genetically Modified Crops." *Journal of Responsible Innovation* 3 (3): 282–289. https://doi.org/10.1080/23299460.2016.1255700.

Macnaghten, Phil. 2020. *The Making of Responsible Innovation*. Cambridge: Cambridge University Press. https://doi.org/10.1017/9781108871044.

Macnaghten, Phil. 2022. "Models of Science Policy: From the Linear Model to Responsible Research and Innovation." In *The Responsibility of Science*, edited by Harald A. Mieg, 93–106. Cham: Springer.

Macnaghten, Phil, Matthew B. Kearnes, and Brian Wynne. 2005. "Nanotechnology, Governance, and Public Deliberation: What Role for the Social Sciences?" *Science Communication* 27 (2): 268–291. https://doi.org/10.1177/1075547005281531.

Macnaghten, Phil, Richard Owen, Jack Stilgoe, Brian Wynne, Adalberto Azevedo, André de Campos, et al. 2014. "Responsible Innovation across Borders: Tensions, Paradoxes and Possibilities." *Journal of Responsible Innovation* 1 (2): 191–199. https://doi.org/10.1080/23299460.2014.922249.

Macq, Hadrien, Céline Parotte, and Pierre Delvenne. 2021. "Exploring Frictions of Participatory Innovation between Sites and Scales." *Science as Culture* 30 (2): 161–171. https://doi.org/10.1080/09505431.2021.1910230.

Marlussen, Åge Olav, Selja Virkkala, and Antti Mäenpää. 2025. "Institutionalization of Responsible Research and Innovation in Universities Seen through System Archetypes." *The Learning Organization: An International Journal* 32 (7): 94–111. https://doi.org/10.1108/TLO-08-2021-0095.

Marschalek, Ilse, Vincent Blok, Michael Bernstein, Robert Braun, Joshua Cohen, Margit Hofer, et al. 2022. "The Social lab as a Method for Experimental Engagement in Participatory Research." *Journal of Responsible Innovation* 9 (3): 419–442. https://doi.org/10.1080/23299460.2022.2119003.

McCampbell, Mariette, Julius Adewopo, Laurens Klerkx, and Cees Leeuwis. 2021. "Are Farmers Ready to use Phone-Based Digital Tools for Agronomic Advice? Ex-Ante User Readiness Assessment Using the Case of Rwandan Banana Farmers." *Journal of Agricultural Education and Extension* 29 (1): 29–51. https://doi.org/10.1080/1389224X.2021.1984955.

McGuire, Erin, Maha Al-Zu'bi, Maria Boa-Alvarado, Thi Thu Giang Luu, Janelle M. Sylvester, and Eva Mariana Valencia Leñero. 2024a. "Equity Principles: Using Social Theory for More Effective Social Transformation in Agricultural Research for Development." *Agricultural Systems* 218:103999. https://doi.org/10.1016/j.agsy.2024.103999.

McGuire, Erin, Hanna Ewell, Arwen Bailey, Eva Marina Valencia, Thi Thu Giang Luu, Janelle Marie Slyvester, et al. 2025. "Breaking Biases and Building Momentum for Transforming Agricultural Research for Development Practices: Recommendations and Research Opportunities." *Sustainable Agriculture* 3:1. https://doi.org/10.1038/s44264-024-00044-y.

McGuire, Erin, Cees Leeuwis, Anne M. Rietveld, and Béla Teeken. 2024b. "Anticipating Social Differentiation and Unintended Consequences in Scaling Initiatives Using GenderUp, a Method to Support Responsible Scaling." *Agricultural Systems* 215:103866. https://doi.org/10.1016/j.agsy.2024.103866.

McGuire, Erin, Anne M. Rietveld, Amanda Crump, and Cees Leeuwis. 2022. "Anticipating Gender Impacts in Scaling Innovations for Agriculture: Insights from the Literature." *World Development Perspectives* 25:100386. https://doi.org/10.1016/j.wdp.2021.100386.

McLean, Robert, and John Gargani. 2019. *Scaling Impact: Innovation for the Public Good*. New York: Routledge.

Mockshell, Jonathan, and Josey Kamanda. 2018. "Beyond the Agroecological and Sustainable Agricultural Intensification Debate: Is Blended Sustainability the way Forward?" *International Journal of Agricultural Sustainability* 16:127–149. https://doi.org/10.1080/14735903.2018.1448047.

Mody, Cyrus. 2016. *The Long Arm of Moore's Law: Microelectronics and American Science*. Cambridge: The MIT Press.

Moore, Michele-Lee, Darcy J. Riddell, and Dana Vocisano. 2015. "Scaling Out, Scaling Up, Scaling Deep: Strategies of Non-profits in Advancing Systemic Social Innovation." *Journal of Corporate Citizenship* 58:67–84. https://doi.org/10.9774/gleaf.4700.2015.ju.00009.

Nygren, Jens, Elena Zukauskaite, and Niklas Westberg. 2018. "User Participation in Coproduction of Health Innovation: Proposal for a Synergy Project." *JMIR Research Protocols* 7 (5): e9322. https://doi.org/10.2196/resprot.9322.

Oria, Prisca A., Alexandra Hiscox, Jane Alaii, Margaret Ayugi, Wolfgang Richard Mukabana, Willem Takken, and Cees Leeuwis. 2014. "Tracking the Mutual Shaping of the Technical and Social Dimensions of Solar-Powered Mosquito Trapping Systems (SMoTS) for Malaria Control on Rusinga Island, Western Kenya." *Parasites & Vectors* 7:523. https://doi.org/10.1186/s13071-014-0523-5.

Oria, Prisca A., Michiel Wijnands, Jane Alaii, and Cees Leeuwis. 2018. "Options for Sustaining Solar-Powered Mosquito Trapping Systems on Rusinga Island, Western Kenya: A Social Dilemma Analysis." *BMC Public Health* 18 (1): 329. https://doi.org/10.1186/s12889-018-5218-y.

Ortega, Natalia, Ariadna Curto, Asya Dimitrova, Jovito Nunes, Davide Rasella, Charfudin Sacoor, and Cathryn Tonne. 2021. "Health and Environmental Impacts of Replacing Kerosene-Based Lighting with Renewable Electricity in East Africa." *Energy for Sustainable Development* 63:16–23. https://doi.org/10.1016/j.esd.2021.05.004.

Owen, Richard, Mario Pansera, and Phil Macnaghten. 2021a. "Organisational Institutionalisation of Responsible Innovation." *Research Policy* 50 (1): 104132. https://doi.org/10.1016/j.respol.2020.104132.
Owen, Richard, René von Schomberg, and Phil Macnaghten. 2021b. "An Unfinished Journey? Reflections on a Decade of Responsible Research and Innovation." *Journal of Responsible Innovation* 8 (2): 217–233. https://doi.org/10.1080/23299460.2021.1948789.
Pansera, Mario, Richard Owen, Darian Meacham, and Vivienne Kuh. 2020. "Embedding Responsible Innovation within Synthetic Biology Research and Innovation: Insights from a UK Multi-disciplinary Research Centre." *Journal of Responsible Innovation* 7 (3): 384–409. https://doi.org/10.1080/23299460.2020.1785678.
Petesch, Patti, Renne Bullock, Shelley Feldman, Lone Badstue, Anne Rietveld, Wenda Bauchspies, et al. 2018. "Local Normative Climate Shaping Agency and Agricultural Livelihoods in sub-saharan Africa." *Journal of Gender, Agriculture and Food Security* 3 (1): 108–130.
Pfotenhauer, Sebastian, and Sheila Jasanoff. 2017. "Traveling Imaginaries. The 'Practice Turn' in Innovation Policy and the Global Circulation of Innovation Models." In *The Routledge Handbook of the Political Economy of Science*, edited by David Tyfield, Rebecca Lave, Samuel Randalls, and Charles Thorpe, 416–428. London: Routledge.
Pfotenhauer, Sebastian, Brice Laurent, Kyriaki Papageorgiou, and Jack Stilgoe. 2022. "The Politics of Scaling." *Social Studies of Science* 52 (1): 3–34. https://doi.org/10.1177/03063127211048945.
Pimentel, David. 1996. "Green Revolution Agriculture and Chemical Hazards." *Science of the Total Environment* 188: S86–S98. https://doi.org/10.1016/0048-9697(96)05280-1.
Pinch, Trevor J., and Wiebe E. Bijker. 1987. "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other." In *The Social Construction of Technological Systems*, edited by Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch, 17–50. Cambridge, MA: The MIT Press.
Politi, Vincenzo, and Alexei Grinbaum. 2020. "The Distribution of Ethical Labor in the Scientific Community." *Journal of Responsible Innovation* 7 (3): 263–279. https://doi.org/10.1080/23299460.2020.1724357.
Reichelt, Nicole, and Ruth Nettle. 2023. "Practice Insights for the Responsible Adoption of Smart Farming Technologies Using a Participatory Technology Assessment Approach: The Case of Virtual Herding Technology in Australia." *Agricultural Systems* 206 (2023): 103592. https://doi.org/10.1016/j.agsy.2022.103592.
Reijers, Wessel, David Wright, Philip Brey, Karsten Weber, Rowena Rodrigues, Declan O'Sullivan, and Bert Gordijn. 2018. "Methods for Practising Ethics in Research and Innovation: A Literature Review, Critical Analysis and Recommendations." *Science and Engineering Ethics* 24:1437–1481. https://doi.org/10.1007/s11948-017-9961-8.
Rietveld, Anne M., and Margreet van der Burg. 2021. "Separate and Joint Interests: Understanding Gendered Innovation Processes in Ugandan Farm Systems." *Frontiers in Sustainable Food Systems* 5:666051. https://doi.org/10.3389/fsufs.2021.666051.
Rietveld, Anne M., Margreet van der Burg, and Jeroen C. J. Groot. 2020. "Bridging Youth and Gender Studies to Analyse Rural Young Women and Men's Livelihood Pathways in Central Uganda." *Journal of Rural Studies* 75:152–163.
Rinscheid, Adrian, Daniel Rosenbloom, Jochen Markard, and Bruno Turnheim. 2021. "From Terminating to Transforming: The Role of Phase-out in Sustainability Transitions." *Environmental Innovation and Societal Transitions* 41:27–31. https://doi.org/10.1016/j.eist.2021.10.019.
Rip, Arie. 2018. *Futures of Science and Technology in Society*. Wiesbaden: Springer Nature.
Ritzer, George. 1996. "The McDonaldization Thesis: Is Expansion Inevitable?" *International Sociology* 11 (3): 291–308. https://doi.org/10.1177/026858096011003002.
Robinson, Douglas K. K., Susana Borrás, and Wouter P. C. Boon. 2025. "Reimagining Diffusion: Eight Building Blocks for Reconceptualising the Generalisation of Innovation in Society." *Technological Forecasting and Social Change* 213:123844. https://doi.org/10.1016/j.techfore.2024.123844.
Rodríguez, Sánchez, Ana María, Malcolm MacLachlan, and Aude Brus. 2021. "The Coordinates of Scaling: Facilitating Inclusive Innovation." *Systems Research and Behavioral Science* 38 (6): 833–850. https://doi.org/10.1002/sres.2740.
Rogers, Everett. 1962. *Diffusion of Innovations*. New York: Free Press of Glencoe.
Rogers-Hayden, Tee, and Nick Pidgeon. 2007. "Moving Engagement 'Upstream'? Nanotechnologies and the Royal Society and Royal Academy of Engineering's Inquiry." *Public Understanding of Science* 16 (3): 345–364. https://doi.org/10.1177/0963662506076141.
Ronner, Esther, James Sumberg, Dominic Glover, Katrien Descheemaeker, Conny Almekinders, Bettina I. G. Haussmann, et al. 2021. "Basket of Options: Unpacking the Concept." *Outlook on Agriculture* 50 (2): 116–124. https://doi.org/10.1177/00307270211019427.
Röling, Niels G. 1988. *Extension Science: Information System in Agricultural Development*. Cambridge: Cambridge University Press.
Sartas, Murat, Marc Schut, Claudio Proietti, Graham Thiele, and Cees Leeuwis. 2020. "Scaling Readiness: Science and Practice of an Approach to Enhance Impact of Research for Development." *Agricultural Systems* 183:102874. https://doi.org/10.1016/j.agsy.2020.102874.
Schuijff, Mirjam, and Anne M. Dijkstra. 2020. "Practices of Responsible Research and Innovation: A Review." *Science and Engineering Ethics* 26:533–574. https://doi.org/10.1007/s11948-019-00167-3.
Schut, Marc, Julien Colomer, Emma Proud, Enrico Bonaiuti, Iddo Dror, Edwin Kang'ethe, et al. 2024. "Innovation Portfolio Management for Responsible Food Systems Transformation in the Public Sector: Lessons, Results and Recommendations from CGIAR." *Agricultural Systems* 216:103907. https://doi.org/10.1016/j.agsy.2024.103907.

Schut, Marc, Cees Leeuwis, and Graham Thiele. 2020. “Science of Scaling: Understanding and Guiding the Scaling of Innovation for Societal Outcomes.” *Agricultural Systems* 184:102908. https://doi.org/10.1016/j.agsy.2020.102908.
Shanley, Danielle. 2022. "Making responsibility matter: the emergence of responsible innovation as an intellectual movement." Diss., Maastricht University. https://doi.org/10.26481/dis.20221208ds.
Sideri, Katerina. 2024. “mRNA Vaccine Politics: Responsible Governance Coordination for Vaccine Innovation in Times of Urgency.” *Journal of Responsible Innovation* 11 (1): 2425121. https://doi.org/10.1080/23299460.2024.2425121.
Singh, Shiv Pratap, Laxman P. J. Gite, and Nidhi Agarwal. 2006. “Improved Farm Tools and Equipment for Women Workers for Increased Productivity and Reduced Drudgery.” *Gender. Technology and Development* 10 (2): 229–244. https://doi.org/10.1177/097185240601000204.
Smolka, Mareike, and Stefan Böschen. 2023. “Responsible Innovation Ecosystem Governance: Socio-Technical Integration Research for Systems-Level Capacity Building.” *Journal of Responsible Innovation* 10 (1): 2207937. https://doi.org/10.1080/23299460.2023.2207937.
Smolka, Mareike, Tess Doezema, and Lucien von Schomberg. 2024a. “Critique in, for, with, and of Responsible Innovation.” *Journal of Responsible Innovation* 11 (1): 2373922. https://doi.org/10.1080/23299460.2024.2373922.
Smolka, Mareike, Philipp Neudert, Frieder Bögner, Wenzel Mehnert, Phil Macnaghten, and Stefan Böschen. 2026. “Anticipatory Alignment Work: The Politics of Anticipation in an Emerging Innovation Ecosystem of Neuromorphic Computing.” *Futures* 176:103756. https://doi.org/10.1016/j.futures.2025.103756.
Smolka, Mareike, Lennart Stoepel, Jasmin Quill, Thorsten Wahlbrink, Julia Floehr, Stefan Böschen, et al. 2024b. “Transdisciplinary development of neuromorphic computing hardware for Artificial Intelligence applications: technological, economic, societal, and environmental dimensions of transformation in the NeuroSys Cluster4Future.” In *Transformation towards Sustainability - a Novel Interdisciplinary Framework from RWTH Aachen University*, edited by Peter Letmathe, Christine Roll, Almut Balleer, Stefan Böschen, Wolfgang Breuer, and Agnes Förster, 271–301. New York: Springer. https://doi.org/10.26481/dis.20221208ds.
Stahl, Bernd Carsten. 2022. “Responsible Innovation Ecosystems: Ethical Implications of the Application of the Ecosystem Concept to Artificial Intelligence.” *International Journal of Information Management* 62:102441. https://doi.org/10.1016/j.ijinfomgt.2021.102441.
Stahl, Bernd Carsten, Tonii Leach, Oluyinka Oyeniji, and George Ogoh. 2023. “AI Policy as a Response to AI Ethics? Addressing Ethical Issues in the Development of AI Policies in North Africa.” In *Responsible AI in Africa. Challenges and Opportunities*, edited by Damian Okaibedi Eke, Kutoma Wakunama, and Simisola Akintoye, 141–168. Cham: Palgrave Macmillan.
Stark, Anthony, Fred Gale, and Hannah Murphy-Gregory. 2023. “Just Transitions’ Meanings: A Systematic Review.” *Society & Natural Resources* 36 (10): 1277–1297. https://doi.org/10.1080/08941920.2023.2207166.
Stilgoe, Jack, Richard Owen, and Phil Macnaghten. 2013. “Developing a Framework for Responsible Innovation.” *Research Policy* 42 (9): 1568–1580. https://doi.org/10.1016/j.respol.2013.05.008.
Stirling, Andy. 2008. “‘Opening Up’ and ‘Closing Down’: Power, Participation, and Pluralism in the Social Appraisal of Technology.” *Science, Technology & Human Values* 33 (2): 262–294. https://doi.org/10.1177/0162243907311265.
Stirling, Andy. 2009. “Direction, Distribution and Diversity! Pluralising Progress in Innovation, Sustainability and Development.” STEPS Working Paper 32. Brighton: STEPS Centre.
Stirling, Andy. 2011. “Pluralising Progress: From Integrative Transitions to Transformative Diversity.” *Environmental Innovation and Societal Transitions* 1 (1): 82–88. https://doi.org/10.1016/j.eist.2011.03.005.
Stirling, Andy. 2014. “Transforming Power: Social Science and the Politics of Energy Choices.” *Energy Research & Social Science* 1:83–95. https://doi.org/10.1016/j.erss.2014.02.001.
Sukhera, Javeed. 2022. “Narrative Reviews: Flexible, Rigorous, and Practical.” *Journal of Graduate Medical Education* 14 (4): 414–417. https://doi.org/10.4300/JGME-D-22-00480.1.
Sumberg, James, and Ken Giller. 2022. “What Is ‘Conventional’ Agriculture?” *Global Food Security* 32: 100617, https://doi.org/10.1016/j.gfs.2022.100617.
Sumberg, James, John Thompson, and Philip Woodhouse. 2012. “Why Agronomy in the Developing World Has Become Contentious.” *Agriculture and Human Values* 30 (1): 71–83. https://doi.org/10.1007/s10460-012-9376-8.
Tait, Joyce. 2017. “From Responsible Research to Responsble Innovation: Challenges in Implementation.” *Engineering Biology* 1 (1): 7–11. https://doi.org/10.1049/enb.2017.0010.
Timmermans, Job, Emad Yaghmaei, Bernd Carsten Stahl, and Alexander Brem. 2017. “Research and Innovation Processes Revisited – Networked Responsibility in Industry.” *Sustainability Accounting, Management and Policy Journal* 8 (3): 307–334. https://doi.org/10.1108/SAMPJ-04-2015-0023.
Timu, Anne G., Dismas Manoti, Apurba Shee, and Liangzhi You. 2024. “Impacts of Gender-Inclusive Extension Approaches on Farmer Understanding and Willingness to Pay for Bundled Financial Services.” *Current Research in Environmental Sustainability* 8:100268. https://doi.org/10.1016/j.crsust.2024.100268.
Tschersich, Julia, and Kristiaan P. W. Kok. 2022. “Deepening Democracy for the Governance toward Just Transitions in Agri-Food Systems.” *Environmental Innovation and Societal Transitions* 43:358–374. https://doi.org/10.1016/j.eist.2022.04.012.
Tsing, Anna Lowenhaupt. 2012. “On Nonscalability: The Living World Is Not Amenable to Precision-Nested Scales.” *Common Knowledge* 18 (13): 505–524. https://doi.org/10.1215/0961754X-1630424.

United Nations. 2015. *Transforming Our World: The 2030 Agenda for Sustainable Development*. New York: United Nations.

Valente, Thomas W., and Raquel Fosados. 2006. "Diffusion of Innovations and Network Segmentation: The Part Played by People in Promoting Health." *Sexually Transmitted Diseases* 33 (7 Suppl): S23–S31. https://doi.org/10.1097/01.olq.0000221018.32533.6d.

van den Ban, Anne W., and Helen S. Hawkins. 1996. *Agricultural Extension*. Oxford: Blackwell.

van der Ploeg, and Jan Douwe. 1990. *Labor, Markets, and Agricultural Production*. Boulder: Westview Press.

van Mierlo, Barbara, Barbara Regeer, Mariëtte van Amstel, Marlèn Arkesteijn, Volkert Beekman, Joske Bunders, et al. 2010. "Reflexive Monitoring in Action. A guide for monitoring system innovation projects." Wageningen/ Amsterdam: Communication and Innovation Studies, WUR; Athena Institute, VU.

van Oudheusden, Michiel. 2014. "Where Are the Politics in Responsible Innovation? European Governance, Technology Assessments, and Beyond." *Journal of Responsible Innovation* 1 (1): 67–86. https://doi.org/10.1080/23299460.2014.882097.

Vanlauwe, Bernard, Danny Coyne, James Gockowski, Stefan Hauser, Jeroen Huising, Cargele Masso, Generose Nziguheba, Marc Schut, and Piet Van Asten. 2014. "Sustainable Intensification and the African Smallholder Farmer." *Current Opinion in Environmental Sustainability* 8:15–22. https://doi.org/10.1016/j.cosust.2014.06.001.

Vanlauwe, Bernard, Katrien Descheemaeker, Ken E. Giller, Jeroen Huising, Roeland Merckx, Generose Nziguheba, et al. 2015. "Integrated Soil Fertility Management in sub-saharan Africa: Unravelling Local Adaptation." *SOIL* 1:491–508. https://doi.org/10.5194/soil-1-491-2015.

Vemireddy, Vidya, and Anjali Choudhary. 2021. "A Systematic Review of Labor-Saving Technologies: Implications for Women in Agriculture." *Global Food Security* 29: 100541. https://doi.org/10.1016/j.gfs.2021.100541.

Vermaas, Pieter, Sabine Ammon, and Wenzel Mehnert. 2024. "Toward a Code of Conduct for Technology Ethics Practitioners." *Journal of Responsible Innovation* 12 (1): 2440958. https://doi.org/10.1080/23299460.2024.2440958.

von Hippel, Eric. 2005. "Democratizing Innovation: The Evolving Phenomenon of User Innovation." *Management Review Quarterly* 55:63–78. https://doi.org/10.1007/s11301-004-0002-8.

Voß, Jan-Peter, and Nina Amelung. 2016. "Innovating Public Participation Methods: Technoscientization and Reflexive Engagement." *Social Studies of Science* 46 (5): 749–772. https://doi.org/10.1177/0306312716641350.

Wang, Xinxin, and Kevin Lo. 2021. "Just Transition: A Conceptual Review." *Energy Research & Social Science* 82:102291. https://doi.org/10.1016/j.erss.2021.102291.

Westermann, Olaf, Wiebke Förch, Philip Thornton, Jana Körner, Laura Cramer, and Bruce Campbell. 2018. "Scaling up Agricultural Interventions: Case Studies of Climate-Smart Agriculture." *Agricultural Systems* 165:283–293. https://doi.org/10.1016/j.agsy.2018.07.007.

Wiarda, Martijn, and Neelke Doorn. 2023. "Responsible Innovation and Societal Challenges: The Multi-scalarity Dilemma." *Journal of Responsible Technology* 16:100072. https://doi.org/10.1016/j.jrt.2023.100072.

Wigboldus, Seerp. 2018. "To Scale, or Not to Scale – That Is Not The only Question: Rethinking the Idea and Practice of Scaling Innovation." Diss., Wageningen University. https://doi.org/10.18174/449586.

Wigboldus, Seerp, Laurens Klerkx, and Cees Leeuwis. 2020. "Making Scale Work for Sustainable Development: A Framework for Responsible Scaling of Agricultural Innovations." In *Science, Technology, and Innovation for Sustainable Development Goals: Insights from Agriculture, Health, Environment, and Energy*, edited by Ademola A. Adenle, Marian R. Chertow, Ellen H. M. Moors, and David J. Pannel, 518–544. New York: Oxford University Press.

Wigboldus, Seerp, Laurens Klerkx, Cees Leeuwis, Marc Schut, Sander Muilerman, and Henk Jochemsen. 2016. "Systemic Perspectives on Scaling Agricultural Innovations. A Review." *Agronomy for Sustainable Development* 36:46. https://doi.org/10.1007/s13593-016-0380-z.

Wigboldus, Seerp, and Cees Leeuwis. 2013. "Towards Responsible Scaling Up and Out in Agricultural Development. An Exploration of Concepts and Principles." Report for the Centre for Development Innovation, Wageningen University & Research.

Woltering, Lennart. 2024. "Stuck on Scale. Rethinking scaling and systems change for AR4D." Diss., Wageningen University. https://doi.org/10.18174/673137.

Woltering, Lennart, Kate Fehlenberg, Bruno Gerard, Jan Ubels, and Larry Cooley. 2019. "Scaling – from 'Reaching Many' to Sustainable Systems Change at Scale: A Critical Shift in Mindset." *Agricultural Systems* 176:102652. https://doi.org/10.1016/j.agsy.2019.102652.

Woltering, Lennart, Eva M. Valencia Leñero, Maria Boa-Alvarado, Jelle van Loon, Jan Ubels, and Cees Leeuwis. 2024. "Supporting a Systems Approach to Scaling for All; Insights from Using the Scaling Scan Tool." *Agricultural Systems* 217:103927. https://doi.org/10.1016/j.agsy.2024.103927.

Zapletal, Amber, Tabytha Wells, Elizabeth Russell, and Mark W. Skinner. 2023. "On the Triple Exclusion of Older Adults during COVID-19: Technology, Digital Literacy and Social Isolation." *Social Sciences & Humanities Open* 8 (1): 100511. https://doi.org/10.1016/j.ssaho.2023.100511.