



Understanding capacities to scale innovations for sustainable development: a learning journey of scaling partnerships in three parts of Africa

S. Wigboldus¹ · M. A. McEwan² · B. van Schagen³ · I. Okike⁴ · T. A. van Mourik³ · A. Rietveld⁵ · T. Amole⁶ · F. Asfaw⁷ · M. C. Hundayehu⁷ · F. Iradukunda⁸ · P. Kulakow⁴ · S. Namanda⁹ · I. Suleman¹⁰ · B. R. Wimba¹¹

Received: 9 March 2021 / Accepted: 20 April 2022 / Published online: 21 May 2022
© The Author(s) 2022

Abstract

Finding out how to scale innovations successfully is high on the agendas of researchers, practitioners and policy makers involved in agricultural development. New approaches and methodologies seek to better address related complexities, but none of them include a systematic perspective on the role of capacity in (partnerships for) scaling innovations. We posit that this has left an important topic insufficiently addressed in relation to partnerships for scaling innovations. The need to address this gap became apparent in the context of the CGIAR Roots, Tubers, and Bananas (RTB) Scaling Fund initiative. This paper presents how we explored ways forward in relation to this by combining three methodological approaches: The Five-Capabilities, Scaling Readiness, and the Multi-Level Perspective on socio-technical innovation. This combined approach—dubbed Capacity for Scaling Innovations (C4SI)—was applied in three projects related to scaling innovations for sweet potato, cassava and banana, involving five countries in Africa. It then discusses implications for a partners-in-scaling perspective, the contribution of scaling innovations to sustainable development, the importance of research organisations considering their own capabilities in partnerships for scaling, and the extent to which C4SI was helpful in the three cases—for example, in decision making. The paper concludes that a capacity perspective on the scaling of innovations should be an essential part of a ‘science of scaling’. Finally, it provides recommendations for using the approach or parts of it in research and intervention practice for scaling, pointing in particular to the need for context-specific adaptation.

Keywords Scaling · Agricultural innovations · Multi-level perspective · Collective capabilities · Scaling readiness

✉ S. Wigboldus
seerp.wigboldus@wur.nl

Extended author information available on the last page of the article

1 Introduction

Scaling (agricultural) innovations is the topic of many recent studies (Ajayi et al., 2018; Jacobs et al., 2018; USAID, 2014; Woltering et al., 2019). This paper connects to this body of literature and knowledge by contributing a capacity perspective on scaling innovations, which has until now hardly been articulated. We make no specific distinction between types of scaling, such as scaling out, and horizontal scaling (Frake & Messina, 2018; Woltering et al., 2019). We use the term to refer to innovations becoming more widely used or practiced, for example social, institutional and technical innovations. In the following, we first position this paper in relation to wider literature on scaling innovations and then explain how we got to defining the need for getting to grips with the way in which capacity issues play out in scaling partnership and how we addressed this need.

The intricate and contested nature of agri-food systems implies that innovation efforts for the purpose of enhanced food security specifically and for enhanced sustainability more generally cannot escape complexity (Dogliotti, 2014; Foran et al., 2014; Reid et al., 2010). Related scaling processes involve an even wider range of interactive dimensions and dynamics which play out differently depending on contexts, leading to a diversity of options for research, policy and development strategies. In the midst of this, the quest for finding and claiming scalable innovations and interventions in the context of sustainable development in general and in the context of agricultural development in particular is in full swing. Most organisations and agencies active in international development have written more than one key document on the topic, such as UNDP (2013), UNICEF (Latimer, 2013), World Bank (e.g. Jonasova & Cooke, 2012), IFAD (Cleaver, 2013), USAID, 2014, and the Gates Foundation (Little, 2012). The idea of scaling innovations is essentially about capitalising on a potential for wider application of something found useful for particular reasons in a specific context. The need for scaling innovations as part of agricultural development is rarely contested. We simply cannot afford investing in research and innovation solely for the purpose of individual development processes. Hence, the quest for ‘making scale work for sustainable development’ (Wigboldus et al., 2020) is high on development agendas. Wigboldus et al. (2016) and Gargani and McLean (2017) argue, however, that there is a common reductionist tendency to equate the scaling of successful innovations with scaling success. In effect it means considering the scaling of (the application of) innovations as the primary road to sustainable development. To address the problematic of reductionist approaches to the role of scaling of innovations in the context of sustainable development, Wigboldus et al. (2016) therefore proposed to approach the idea and practice of scaling innovations more critically (also see Wigboldus, 2018), and call for an approach of *responsible* scaling of innovations which considers ethical and foresight perspectives more seriously than is commonly done.

Meanwhile, in Africa, scaling innovations as the pathway par excellence to sustainable development is a central part of development policies and agendas (e.g. Ajayi et al., 2018; Open African Innovation Research, 2020, as well as the TAAT initiative, <https://taat-africa.org/>). Innovation platforms have often been considered a key instrument for scaling innovations that were developed by research organisations (Totin et al., 2020). Considering what makes for *responsible* scaling of innovations therefore most certainly applies in Africa. Sustainability transitions tend to be reduced to a focus on a massive roll-out of standardised ‘solutions’, which runs counter to the application of resilience principles such as diversity and flexibility (Wigboldus et al., 2021).

One of the frontiers of learning in relation to scaling innovations entails dealing with the complexities involved in scaling innovations. Gargani and McLean (2017), Jacobs et al., (2018), Sartas et al., (2017), and Wigboldus et al., (2016) are among those pointing to such complexities, offering ways of unpacking related dimensions and dynamics such as new perspectives on innovation systems and the role of innovation intermediaries (e.g. Klerkx et al., 2012) and scaling intermediaries (Wigboldus et al., 2016). However, in doing so, they do not elaborate sufficiently on how this would affect the capacity to engage with such complexities as *partners in scaling*. As (public–private) partnerships feature prominently in sustainability transitions, we also need to understand what is involved in engaging effectively and appropriately as partners in scaling innovations for sustainable development. An appropriate framework for doing so is lacking.

In early 2018, the CGIAR Research Program on Roots, Tubers and Bananas (RTB) launched a special fund (RTB Scaling Fund) aimed at achieving three objectives, interactively and simultaneously, in a number of scaling projects: (1) Seeing selected innovations being applied at a significantly larger scale in a variety of contexts; (2) Seeing scaling processes contributing positively to people’s livelihoods; and (3) Embedding these results in a process of forward learning about ways to effectively engage with related scaling processes as a research organisation. Three scaling projects were begun in 2018 in six countries in Africa. As the projects gained momentum, partnership and related capacity issues became a central concern in each of these projects. The partnerships approach applied at that time was found to provide insufficient guidance particularly in terms of decision making, which prompted us to look for *complementary* approaches and methodologies that could support these projects (and their related partnerships).

General approaches to capacity development, partnership assessments (Caplan et al., 2007; Horton et al., 2009), and multi-stakeholder processes (Brouwer & Woodhill, 2015) were found to be partially helpful in providing insights related to scaling capacity, partnership dynamics, and multi-stakeholder processes in general. However, they have not been connected to the specific environment of partnerships for scaling innovations, whereas Muilerman et al., (2018) points to the need for specific approaches to (management) processes related to scaling innovations, considering their dynamics to be completely different to those of general (innovation) projects. Chandy and Linn (2011) refer to capacity for scaling, but do systematically elaborate upon it. The approach of *innovation platforms* (Adekunle et al., 2016; Kilelu et al., 2013) often includes perspectives on scaling-related innovations without, however, elaborating this further towards a view on related collective capabilities to scale the innovation for the purpose of contributing to sustainable development.

Over the past decade, the multi-level perspective (MLP) on socio-technical innovations (Geels, 2002) has increasingly been used to interpret processes that introduce agricultural innovations (Blesh & Wolf, 2014; Hinrichs 2014; Morrissey et al., 2014) and related scaling processes (Wigboldus et al., 2016) within a broader system change perspective. Engaging with the kind of dynamics identified in MLP requires particular capacity, not just as individual organisations, but specifically in the context of broader partnerships. This raises questions about what creates capacity as partners in scaling to engage effectively and appropriately with such system dynamics. The multi-level perspective presents an interesting methodology for approaching the capacity to engage with scaling innovations from a systems perspective, but it does not provide tools to elaborate a perspective on taking innovations to scale as partners in scaling.

We concluded that there are several existing approaches that provide useful perspectives on capacity, on scaling innovations and on contextualising processes for scaling

innovations in support of sustainability transitions. However, none of these approaches integrate these angles into a systematic perspective on capacity (as partners in scaling) for scaling innovations. We therefore developed an approach and related capacity framework based on building blocks from the existing approaches. This paper presents the capacity for scaling innovations (C4SI) approach and the way in which it was applied in three projects in Africa, the outcomes of its application and related wider lessons that we suggest are of potential use for future scaling initiatives.

Given the specific partnership context of the projects to which this paper pertains, we were especially interested in exploring a capacity perspective on being *partners in scaling* for sustainable development. This is not merely about being partners in scaling a particular innovation (package) as such. Even though there is a widespread tendency to treat the scaling of particular innovations as a purpose in itself (Gargani & McLean, 2017; Wigboldus, 2018), it should never be. It is a means to an end, and we define that end as ‘sustainable development’ since the focus of the three cases was that the wider application (scaling) of proposed innovations would contribute to this.

In the following, we introduce C4SI as a methodological approach and explain how we applied it in the three projects (Sect. 2). Results obtained from applying C4SI in these projects are presented in a summary overview in Sect. 3. Section 4 reflects on issues in operationalising C4SI, and discusses findings in their own right, the usefulness of C4SI as experienced by/in relation to the study, the role of research organisations, and C4SI’s potential contribution to a science of scaling. Section five revisits the purpose of this paper and related research questions, summarising recommendations for future scaling initiatives.

2 Methodology

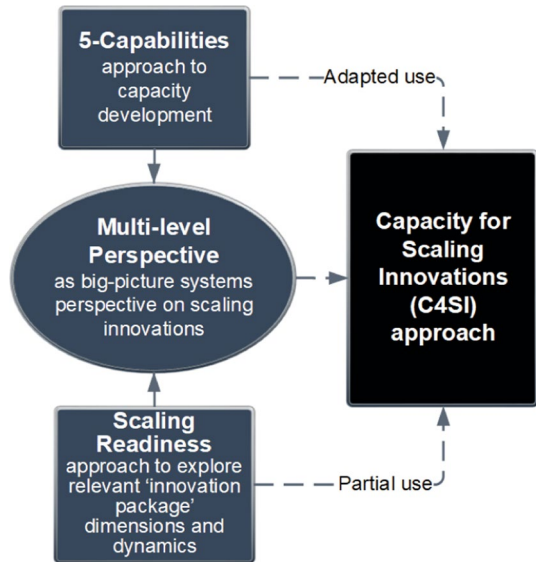
In this section, we introduce the capacity for scaling innovations (C4SI) approach and explain how we applied it in the context of three projects in Africa.

2.1 The capacity for scaling innovations (C4SI) approach and its development

The development of the C4SI approach was guided by the following research objectives: It should help to (1) Conceptualise capacity to scale innovations for sustainable development; (2) Articulate relevant issues in scaling-related management and partnerships; (3) Learn about conditions that shape capacity to scale innovations for sustainable development; and (4) Translate related findings into insights regarding the formation of partnerships for scaling the innovation, and the role of research organisations in this process.

Three approaches and frameworks interactively helped shape C4SI. We considered each as not providing sufficient guidance by itself, but in combination we considered them capable of addressing the main issues regarding capacity to scale innovations for sustainable development. They are (1) The five core capabilities (5 Cs) approach which focuses on capacity and capacity development, (2) The multi-level perspective (MLP) which provides a (big-picture) systems perspective on innovation and scaling, and (3) Scaling readiness, which focuses on specific aspects of scaling processes (Fig. 1). We briefly introduce each in the following subsections.

Fig. 1 The three perspectives underpinning C4SI



2.1.1 The five core capabilities approach

In a study on capacity for (sustainable) development, Baser and Morgan (2008) concluded that capacity in such a context can be understood as *the outcome of five interactive capabilities, which was captured in the Five Core Capabilities Framework (5Cs framework)*. The five core capabilities are considered to play out in every organisation and social system. They are strongly interrelated and provide a context-specific basis for assessing a situation (Keijzer et al., 2011). The capability to achieve coherence may be considered pivotal in unlocking what the other capabilities can bring to bear on the combined capacity. This may relate to the critical role of actors who are capable in this area and thereby able to make all capabilities come together towards a collective capacity.

The capabilities are shaped by individual and collective skills, competencies and resources. This means capacity is understood as *the emerging outcome of the status of and the interplay between the five core capabilities and what is shaping those capabilities*. It is essential to understand that this is a perspective on collective capabilities. The capabilities of one actor may be weak in one area, but strong in another, and the opposite may apply to another actor. Collectively, their capacity may then still be considered strong.

The 5Cs framework can be and has been applied to a range of organisation types across different contexts (e.g. Huisman & Ruijschoot, 2013; Keijzer et al., 2011; Oosten et al., 2021). Capacity can only be understood appropriately in relation to the specific context and in view of specific tasks and/or challenges faced (Bebbington, 1999; Deneulin & Shahani, 2009; OECD, 2006).

Translating the 5Cs approach to the context of scaling innovations required re-focusing four of the five capabilities, adapting the orientation of the fifth, and adding one scaling-specific capability. The resulting six capabilities for scaling innovations are:

1. Capability to relate and partner
2. Capability to resource and act

Table 1 Brief description of the capabilities involved in scaling

Capabilities	Short description of what it involves
Capability to relate and partner in scaling the innovation	Shared values and interests (ownership feeling). Trust, social credibility and reputation. Participation in collaborative arrangements
Capability to resource and act for scaling the innovation	Clear purpose and focus. Mapped-out direction of anticipated change. Capacity building and technical backstopping. Financial support. Consensus on implementation across levels (e.g. within government ministry)
Capability to adapt and navigate challenges in scaling the innovation	Learning and fostering internal dialogue for continuous innovation. Repositioning/reconfiguring the organisation/partnership
Capability to balance diversity and coherence among partners in scaling the innovation	Mutual respect. Manage diversity/productive disagreement. Coordinating leadership. Multi-stakeholder collaboration. Leveraging power relationships
Capability to make scaling the innovation work for development results	Effective benefits for livelihoods. Responsible scaling of innovation. Inclusive development focus. Public-private partnership. Enabling economic/market environment
Capability to anchor the innovation in institutions for continued scaling	Policy alignment and integration. Recognising connecting to and mobilising relevant institutions

3. Capability to adapt and navigate challenges
4. Capability to balance diversity and coherence among partners
5. Capability to make scaling contribute to sustainable development
6. Capability to anchor the innovation in institutions (for continued scaling)

Table 1 summarises our understanding of what the capabilities refer to. We adapted the ‘capability to achieve development results’ to a ‘capability to make scaling contribute to sustainable development’ to ensure it would relate to more than just scaling the innovation as an end in itself (Blok & Lemmens, 2015; Leach et al., 2012; Matt et al., 2017). The adapted capability description activates a capacity perspective within a systems approach to scaling innovations, acknowledging that this is not about a standalone ‘roll-out’ intervention process, but about a positioning in a variety of contexts in view of related system configurations and dynamics (Coe et al., 2014; Garb & Friedlander, 2014; Gargani & McLean, 2017; Wigboldus et al., 2016). It also activates a perspective on responsible scaling by *not* assuming that an innovation that proved useful in a particular context, for particular actors and applied at a particular scale level, will necessarily contribute to sustainable development at other scale levels, for other actors, and when applied in new contexts (cf. Avelino & Wittmayer, 2015; Von Schomberg, 2013).

We added the ‘capability to anchor the innovation in institutions’ as a capability which was found to be a crucial part of capacity to scale innovations (i.e. the connection between scaling and system change) (e.g. Hermans et al., 2013; Muilerman et al., 2018). It could not be integrated into any one of the five core capabilities as described by Baser and Morgan (2008) without losing its specific focus and implications for understanding capacity for scaling innovations.

2.1.2 The multi-level perspective (MLP) on socio-technical innovation

MLP creates a canvas for picturing processes of innovation, their (attempted) introduction at scale, and the way this interacts with relevant system (regime) conditions and transitions (El Bilali, 2019; Wigboldus et al., 2016). It distinguishes three levels:

- a *niche* level, which is about innovation processes and resulting innovations; it concerns conditions that can be influenced and changed more easily.
- a *regime* level, which is about socio-technical systems, such as farming systems, where particular social and technical conditions shape dominant ways of doing things; it concerns conditions that are much harder to influence and change.
- a *landscape* level, which is about the wider context in which particular system change, as well as the introduction of innovations, takes place; it includes wider political and environmental conditions that are generally beyond reach in terms of influencing and changing, but do co-shape the context for scaling the innovation.

MLP articulates the socio-technical system and wider context conditions and dynamics that partners in scaling will need to navigate by applying their collective capabilities. This is not just about aiming for higher numbers of people applying/using the proposed innovation, but also about seeing it anchored in relevant (formal and informal) institutions. This involves a 'regime' change, for example, in terms of (pre)dominant practices in farming systems or innovation systems. The core capabilities relate to different dimensions of MLP, though they can often be linked to more than one particular part of it (Fig. 2).

2.1.3 Scaling readiness

Scaling readiness (Sartas et al., 2020a, b) connects to MLP in two ways. It helps to unpack dimensions of the niche innovation in terms of readiness for application/use at scale, as well as what wider regime change will be needed to enable use/application at scale.

Scaling readiness considers the scaling of innovations as a complex process in which multiple social and technical innovations are needed to shape an environment in which the core innovation can be used or applied at scale. For example, a specific technology to control a crop disease may only be applied at scale if appropriate regulatory frameworks and adapted cropping system approaches are put in place. Unless such wider innovation needs are addressed, the core innovation stands little chance of being used or applied at scale.

Another dimension of scaling readiness relates to the core innovation. For example, it may not have been tested in a variety of contexts or with different types of users, which may affect its readiness to be used or practised more widely. The two dimensions together are referred to as the *innovation package*. This is not a full description of the scaling readiness approach. The three cases applied an early version of scaling readiness in the initial assessment and formulation of scaling strategies. Scaling readiness as an approach has been further developed since then Sartas et al. (2020a, b).

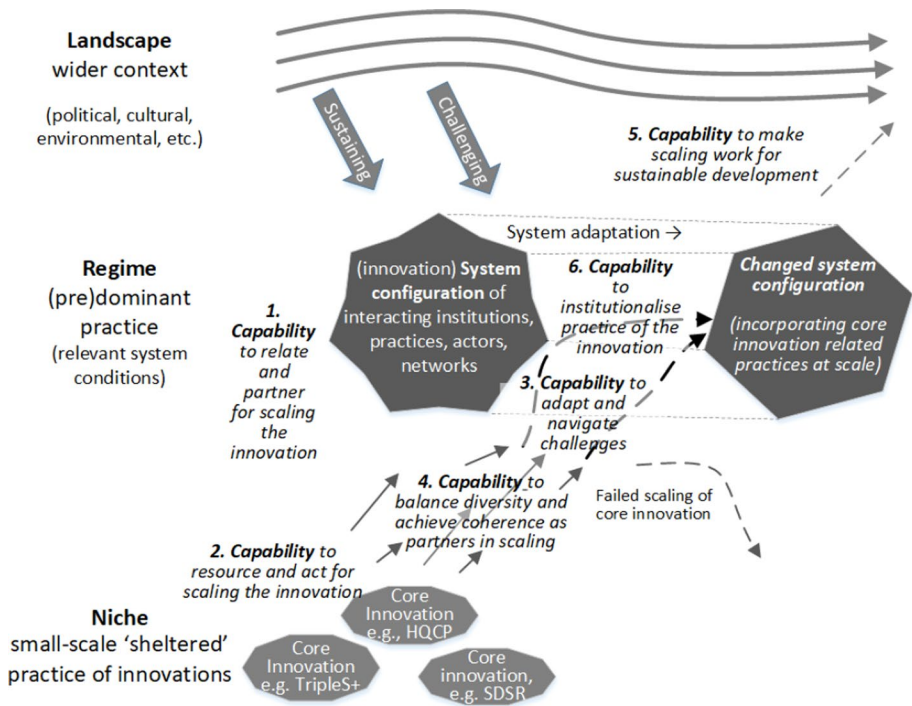


Fig. 2 Illustration of how core capabilities connect to the multi-level perspective

2.2 Application context

At the time the scaling projects started, and also during the initial stages of partnership building, C4SI was not yet fully in place to support its application. The more articulate and elaborate response to capacity needs emerged during the navigating phase and motivated the development of C4SI.

C4SI evolved in the context of the RTB Scaling Fund. This created a specific environment that entailed four key forms of support and preparation: First, funding for two years was committed to achieve agreed objectives related to scaling. Second, scaling champions were recruited—dedicated staff who would support each of the scaling projects throughout the two-year implementation cycle. These champions were part of a small team within each of the organisations hosting the scaling projects (Bioversity, IITA/ILRI, and CIP), and their task was to play a key coordinating and implementing role in partnership processes to scale the innovation work. Third, scaling readiness was used to better understand what the scaling project and related partnerships would need to be prepared for in terms of different aspects of the core innovation itself (whether ready or not to take to scale), as well as to understand wider innovation (change) processes that would need to be put into place; this informed the development of an initial scaling strategy. Fourth, a formative learning approach was taken, involving systematic learning updates and periodic reflection meetings with partners, which informed adaptive management as well as the development of the approach that we present in this paper.

Table 2 Summary information on the three cases to which C4SI was applied

Project focus/title	High-quality cassava peels (HQCP) processing and use	Storing sweet potato roots in dry sand and sprouting (Triple S PLUS) CIP (2019)	Single diseased stem removal (SDSR)
Geography	Nigeria (starting in Oyo state)	Southern Ethiopia and northern Ghana	Burundi, DR Congo (South Kivu), Rwanda and Uganda (we focus in this paper on experiences in Burundi and DR Congo)
Scaling project host	International Institute of Tropical Agri-culture (IITA)	International Potato Center (CIP)	Bioversity International
Issue addressed	Large volumes of cassava peel are left as waste causing environmental pollution while there is the potential to use it as an alternative source of animal feed to mitigate feed scarcity	In areas with a long dry season, many farmers have insufficient quantities of quality sweet potato planting material at the start of the rains	Banana Xanthomonas Wilt disease (BXW) threatens production of all types of banana in the East-African Highlands, which is of key concern for farmers' livelihoods
Proposed innovation	High Quality Cassava Peels processing technique to dramatically reduce drying time, processing time, while improving product safety and hygiene by minimizing cyanide content and preventing growth of mycotoxins (Okike et al., 2022)	Triple S PLUS: Storage in Sand and Sprouting to initiate development and growth of healthy shoots for timely production of clean planting material of orange-fleshed sweet potato (OFSP) and non-OFSP varieties Namanda et al. (2013). The PLUS refers to the package of good agricultural practices (GAPs) around the use of Triple S (McEwan et al., 2022)	Single Diseased Stem Removal (SDSR) to control / manage the disease and maintain production
Envisioned benefits if applied at scale	1. Clean environment and air, clean underground water 2. More animal feed 3. More income for processors 4. More maize and cereals released for human consumption. 5. Greenhouse gas emission from rotting heaps averted	Using Triple S allows farmers to: 1. Increase availability of planting material; 2. Plant early, obtain higher yields and extend availability of OFSP roots for improved food and nutrition security, and income	1. Maintains productivity and income levels of banana producing households; 2. Improves food security; 3. Maintains soil cover and thus reduced risk of erosion
Original scaling targets (direct) by 2020	2,000 investors trained in HQCP processing; major feed millers incorporate HQCP in feed rations; 200 investors linked to HQCP commerce	Ghana: 30,000 farmers; Ethiopia: 10,800 farmers	Burundi: 19,000 farmers + SDSR is institutionalised in government national policy of DRC: 22,800 Households

Table 2 (continued)

Project focus/title	High-quality cassava peels (HQCP) processing and use	Storing sweet potato roots in dry sand and sprouting (Triple S PLUS) CIP (2019)	Single diseased stem removal (SDSR)
Project human resources to support this innovation	0.5 FTE	Ethiopia & Regional: 1 FTE Ghana: 1.82 FTE	Burundi: 1.3 FTE DRC: 1.25 FTE
Available project funds	\$400,000	\$700,000	\$700,000

The initial operationalisation of C4SI was applied in the three projects (Table 2) and refined during the implementation process.

2.3 Application process

Some innovations may contribute to sustainable development only if applied at a limited scale or only in specific contexts. An assessment along the lines of ‘what if this goes to scale?’ needs to guide decisions on whether it is appropriate to invest in the capacity for scaling the innovation. This assessment was part of the earlier selection processes in the RTB Scaling Fund, and we did not include this in the C4SI application process. It would need to be added to future applications of C4SI in situations where such exploration has not yet been done.

The application process of C4SI involved five iterative steps, meaning that they were not followed in a strict one-directional order. We elaborate on the five steps in the following.

2.3.1 Assessing the nature and context of the innovation to understand capacity needs

This concerns the application of the assessment part of scaling readiness (Sartas et al., 2020a). It involves: (1) Assessing readiness of the innovation in terms of its maturity and its potential applicability outside the original context, and (2) Assessing the extent to which core and complementary innovations are already being used in the relevant context. Core innovations are mainly about the technologies involved, and complementary innovations are about needed enabling-environment conditions, which make (wider) application of the technologies possible. This then informs the identification of bottlenecks for scaling, which forms the basis for choices regarding the necessary partnerships and strategies to address these bottlenecks. Retrospectively, we can also assess the extent to which the initiative, to which this assessment was applied, was appropriately prepared to engage with this. To do so, we used MLP as a sense-making framework. In each of the three cases, the wider context and conditions that were considered of potential relevance to the process of scaling the core innovation were explored. This focused on the following core dimensions: bio-physical, social-cultural, economic, (infra) structures, institutions, societal goals, values, and preferences. These are conditions that may be difficult to influence, but that require appropriate capabilities to adapt and self-renew to navigate challenges.

2.3.2 Assessing capacity for scaling the innovation

Here, we apply the capabilities framework. Collective capabilities as partners in scaling were assessed from two angles: (1) Capabilities of individual partners in scaling, and (2) Collective capabilities of partners in scaling both before (at the start of the scaling project) and after (at close to phase-out of scaling project). Capabilities were elaborated through specific dimensions, which we call ‘abilities’. Indicators were used to guide the assessment of partners’ performance in relation to each of these abilities.

2.3.3 Applying capacity insights towards a scaling strategy

The scaling strategy relates to both the initial strategy as a product emerging out of a process of agreeing on how to be partners in scaling, and to the continuous process of

strategising. For the development of an initial scaling strategy, an interactive workshop with initial partners in scaling provided the first insights into available capacity for scaling the innovation. This initial understanding had to be revisited a number of times.

Considering the nature of the innovation and its context, as well as the available capacity to scale the innovation, we explored the needs for enhancing the capacity to scale the innovation. This assessment was related to the conditions identified through the collective capabilities assessment, but also reflected the need to respond to newly emerging challenges (continuous strategy).

2.3.4 Navigating realities of capacity for scaling the innovation

Through systematic learning/reflection meetings and related updates, the realities of the scaling partnership process were monitored and translated into implications for needed adaptation of strategies and operations. 'Systematic' here means that there was a checklist guiding the reflections, which took place regularly. These interactions allowed for quick responses to unanticipated dynamics, thus allowing for adapting and fine-tuning capacity strengthening efforts. This could also mean involving new partners who already had the needed capabilities.

2.3.5 Evaluating the effectiveness of capacity for achieving scale, institutionalisation, and development impact

This pertains to understanding three process: (1) To what extent is the innovation being applied at a larger scale than before; (2) To what extent have processes of scaling become institutionalised so that they will carry on after the scaling project phases out; and (3) To what extent is a larger-scale application actually contributing to development impact in terms of, for example, better livelihood conditions such as better income. Regular monitoring and evaluation of results informed this step.

2.4 Operationalisation

There are two main ways in which we operationalised C4SI.

First, through formal assessments. These assessments were carried out in two phases: (1) A retrospective assessment of the capacity to scale the innovation at the start of the scaling project (early 2018), and (2) An assessment of the state-of-affairs late summer 2019 as the scaling project started working towards phase-out. The assessments were done with varying involvement of partners in scaling.

Second, through reflection meetings where/at which formal assessments were complemented by discussions as project teams (and in some cases with wider partners) to interpret the information and translate it into implications for (adaptive) management. This was further complemented by insights from regular systematic learning updates.

3 Results

This section presents results from the application of C4SI in the three cases (Table 1). We present the results in accordance with the five key steps as outlined in the previous section.

3.1 Assessing the nature and context of the innovation to understand capacity needs

3.1.1 The nature of the innovation

This stage built strongly on selected elements from the then current version of scaling readiness (Sartas et al., 2017) It was mainly done by the lead actor in the process and did not yet involve wider partners in scaling. It created a reference point, which was revisited in later stages of the process.

Unpacking is about understanding *what* innovation dimensions and dynamics need to be taken into account to understand whether the core innovation is ready for wider use/application (scaling). This involved (1) Considering subcomponents of the core innovation, and (2) Exploring which wider innovation processes would need to take place in order to create an enabling context for use/application of the core innovation at scale.

For example, SDSR as core innovation was divided into three key subcomponents: (1) Regular removal of diseased stems, (2) Tool sterilisation by fire, and (3) Male bud removal. This kind of compartmentalisation helped us sort out which different conditions were required for scaling. Exploring which complementary innovation processes would need to take place involved considering the core innovation in context. For example, we found that the innovation for processing HQCP as a core technology would need to be supported by a range of innovations along the related value chain, if both processing and the ultimate use of HQCP products were to go to scale. This included required innovations in relation to access to credit for future HQCP processors, new formulas for animal feed, which include HQCP flour and the aggregation of cassava peels.

3.1.2 The innovation in context

Assessing in this context is about considering *the extent* to which (1) The core innovation and its subcomponents and (2) The wider innovation context are conducive to scaling (wider use/application) the core innovation. For example, for SDSR subcomponents it became apparent that tool sterilisation by fire posed some issues requiring further fine-tuning and diversifying application options for SDSR. For HQCP, the aggregation of cassava peels was found to be a major bottleneck, which it remains to date. The assessment helped to consider the capabilities needed to address relevant issues.

The process of unpacking and assessing was a prerequisite for considering appropriate scaling strategies, and, only later in the navigation process, informed which capabilities would match related challenges. As C4SI evolved, we realised, for example, how this process of unpacking and assessing could be characterised along the lines of MLP to help consider the scaling process as a sociotechnical transition process. Table 3 translates findings from the unpacking and assessing stages for the HQCP case into an MLP perspective and presents initially defined implications of this in terms of capacity needed to scale the innovation.

Table 3 Translation of the findings of unpacking and assessing the HQCP innovation package (early 2018) into an MLP perspective with illustrations of related capacity needs

Niche readiness assessment	
How ready	Core innovation has been tested and proven to work. Supporting technology already available and used widely for processing cassava flesh into <i>garri</i> —a local staple. Needed machines and materials are common and locally fabricated. What is different, is the input (fresh cassava peels instead of fresh cassava flesh) and product (HQCP instead of <i>garri</i>). A key challenge is the need for aggregation to create sufficient bulk availability. So, readiness considered high for most factors, except for aggregation
Related capacity needs	As the traditional (<i>garri</i>) and emerging product (HQCP) target different consumer niches, there was a crucial need to balance diversity and coherence between partners with differing objectives; and as a new area, seek resources and find common grounds for partnering. Showcasing the results of technical and economic feasibility studies was considered to provide an entry point
Regime readiness assessment	
How ready to 'receive' the core innovation	Though the core innovation as such has been proven to work, and there is clear interest, including on the part of representatives of the private sector, there is still hesitation to apply this at significant scale. An important factor in this is the hurdle of aggregation—it is not yet clear how to navigate this. Moreover, knowledge about opportunities is limited and capital is needed to start up HQCP businesses. Government organisations appear to be quite receptive and open to collaboration, which means that institutionally the regime is quite ready, but technically there are still some lock-ins
Related capacity needs	Need for institutionalisation so that scaling can continue after the IITA/ILRI phase out their related projects. Private sector investors and public institutions such as Agricultural Development Programmes (ADPs) needed to take up further training of interested persons at their locations. As part of bringing coherence, investors are encouraged to form an association from an existing, loose Community of Practice (CoP) and share information on availability and timing of training events
Landscape (wider context) readiness assessment (also see 2.3.1)	
How conducive	The usage of wet peels has been opportunistic—using small quantities that can be obtained in the dry season by spreading on bare floor without any elaborate investment in machines or maintaining feed safety and hygiene. Unless there is an intention to go commercial, this tradition is likely to continue only for households in possession of ruminants
Related capacity needs	Other uses for cassava peels (as organic cement, glue) are still the subject of debates. From a wide lens, capacity is needed to accommodate a diversity of uses/users and maintain a balance. Focus on economic and environmental benefits of improved uses

Table 4 Before (B) and after (A) assessment of collective capabilities of the group of partners in scaling disaggregated by country

Capability	Dimension (abbreviated) <i>(see Table 8 in the Annex for details)</i>	HQCP Nigeria		Triple S PLUS Ethiopia		Triple S PLUS Ghana		SDSR Burundi		SDSR DR Congo	
		B	A	B	A	B	A	B	A	B	A
1. To relate and partner	Relationships and involvement	3	4	4	5	3	4	2	2	4	4
	Agreement	2	4	4	2	3	3	5	5	4	4
	Legitimacy	4	4	4	5	4	4	5	5	2	5
	Alignment	2	4	4	5	4	4	4	5	2	5
	User realities	2	5	5	5	4	4	3	3	4	3
2. To resource and act	Strategies and plans	4	4	3	4	2	3	4	4	3	5
	Consensus	3	5	3	4	3	4	4	3	2	4
	Motivation	3	5	3	3	3	4	3	3	3	4
	Finances	2	3	3	2	3	3	1	2	1	2
	Human resources	3	3	3	2	3	4	4	4	2	4
3. To adapt and navigate challenges	Contextualise	2	4	3	3	3	2	3	4	3	4
	Change path	2	4	3	4	3	3	2	3	3	4
	Adaptive management	2	4	2	2	3	3	4	4	4	4
4. To balance diversity and coherence among partners	Conflict management	5	5	2	5	3	3	2	2	2	5
	Alignment of interests & effort/ Communication	2	4	Com 4	Com 2	4	4	3	5	4	4
5. To make scaling contribute to sustainable development	Leadership	3	4	2	5	3	3	3	3	3	4
	Clear ultimate purpose	2	4	4	3	3	4	4	4	3	4
	System view	2	4	4	3	2	4	3	3	3	3
	Target group benefits	3	4	2	2	3	4	3	3	2	3
6. To anchor the innovation in institutions	Effective monitoring	2	4	3	1	3	4	3	3	3	4
	Connect to institutions	2	4	4	5	4	4	3	3	3	4
	External support	2	3	3	2	4	4	3	3	2	4
	Connect to policy frameworks	-	-	3	3	4	3	2	2	3	3
	Anchoring knowledge	2	3	4	4	4	4	3	3	3	4

1=hardly or none, 2=limited, 3=basic, 4=relatively good, 5=largely the case; Green highlighted cells indicate an improvement of capability over the course of the project, while orange highlighting indicates a decline in capabilities

3.2 Assessing capacity for scaling the innovation

3.2.1 Enhancing understanding about collective capabilities and how these were playing out

This concerns the application of the six core capabilities in assessments. Table 4 presents the results of assessments carried out in each of the projects to diagnose collective capabilities of the partners in scaling. This served to inform discussions and to make sense of the collective capabilities as partners in scaling.

3.2.2 The story behind the numbers

The following elaborates on the story behind the numbers using some illustrative highlights from the cases.

3.2.2.1 Illustrations from the Triple S PLUS case In the Triple S PLUS case in Southern Nations, Nationalities and Peoples’ Region (SNNPR) of Ethiopia, the overall scores for the ability to relate and partner increased in the second assessment. This reflected stronger

relationships among partners and a greater collective understanding of how Triple S PLUS aligned with climate-smart policies and nutrition-sensitive agricultural programmes. There was also a growing acceptance among farmers with respect to the innovation package's legitimacy. However, the lower score in the second assessment regarding the partners' ability to agree reflected the situation where partnerships between organisations—as opposed to relationships with farmers and other partners—were based on 'formal memorandum of understanding' (MoU) agreements.

With respect to the capability to resource and act, initially there was more optimism in Ethiopia about the capability of the government Bureau of Agriculture and Natural Resource Development (BoANRD) to prioritise internal resources for the promotion of Triple S. There had been institutional commitment by senior management, however, political changes at the federal level led to a turnover in senior management in the regional BoANRD, and then a shift in power relations across the different administrative levels. The zonal BoANRDs ranked crops for their extension activities, resulting in sweet potato being prioritised in some zones, but not in others.

In Ghana, the capability to adapt and self-renew was basic and this did not increase in the course of the scaling project. The problem in this case was that partners (a large NGO and their projects, and private sector government organisations) often have their own policy, project cycles, deliverables, and interests, and it can be difficult to diverge from these if that appears to be necessary during the course of the project.

3.2.2.2 Illustrations from the SDSR case In DRC, the improved capability to relate and form partnerships was linked to/associated with the ability categories of 'legitimation' and 'alignment'. Before the scaling partnership, farmers and community leaders in DRC tended to hide and ignore BXW for fear of forced whole mat uprooting (as was formerly promoted in top-down fashion), and/or to avoid stigma. Because SDSR results were visible in a short time, grassroots partners quickly bought in to SDSR, resulting in increased confidence and trust, and their active participation in expanding application of SDSR. The ability to form partnership increased as a result of genuine local appropriation of the SDSR technology.

The capability to resource and act in Burundi (similarly to DRC) was already supported by the fact that bananas are very important for people's livelihoods, as well as a cultural symbol of prosperity, and therefore all partners, especially farmers, have a key interest in maintaining banana productivity. However, expanding application of SDSR to the national level through engagement with policymakers proved much more difficult to achieve, hence, the slightly lower score for 'consensus' after the assessment compared to before. We learned that positive results alone are not always enough to convince policymakers and, in hindsight, we should have engaged with them more, and especially with national research, from an earlier stage in order to test/validate and scale in other provinces as well. This would have required extra funds, which were not available.

3.3 Applying capacity insights towards a scaling strategy

The first step in strategising was taken by the lead organisations and included employing *scaling champions* to support further partnership engagement. This means that the partnership approach to scaling was an a priori choice of the lead organisation. The next step was a highly interactive (two-day) workshop with initial partners to explore opportunities for and possible ways of working as partners in scaling the innovation within the project

timeframe. This also provided an opportunity to check, validate, and adapt earlier steps (of unpacking and assessing) in the process. A rich picture exercise (Checkland and Scholes 1999) supported the exploration of the context of the scaling propositions. Through an interactive visualisation process regarding ‘unlocking the potential of the core innovation at scale’, a shared vision, shared perspectives on pathways to scale, and implications for a shared effort were tentatively agreed upon.

It was at this point that the partners (of the research organisation) started to become partners in scaling. Table 5 summarises the key elements of the strategic follow-up on those initial partnership formation processes.

Although successful workshops took place and partnerships did develop, it became clear during the navigating phase that (partner) capacity for scaling the innovation had not been adequately assessed and addressed. The process of coming to grips with related capacity issues sparked the development of C4SI. For example, navigating hierarchies in government organisations proved more difficult than anticipated and would have benefited from a more carefully considered strategy, notably a related communication strategy and who plays what role in this process.

3.4 Navigating realities of capacities for scaling the innovation

3.4.1 Revisiting assumptions about capacities for scaling

Navigating the scaling process was found to be a continuous process of re-assessing, re-strategising, and formulating new agreements as partners in scaling. It also involved revisiting assumptions about the innovation, the wider context, and/or particular capabilities. For example, in Ghana, it was assumed that orange-fleshed sweet potato vines would be readily available as part of the partners’ programmes, but that turned out not to be the case. This meant that an effort was needed to increase production and improve access to vines. This involved, for example, developing new connections with vine producers (capability to relate), and identifying a private sector seed producer to partner with for increased production capacity.

Through a process of regular reflection, it became clear in all three cases how partnership issues and related capacity for scaling the innovation posed more challenges than anticipated and for which the earlier assessment processes had not prepared the scaling projects sufficiently. In the following sections, we describe two main tools that were developed to support the scaling projects in navigating capacity-related challenges. These are not the only tools applied but do represent the main type of tools used.

3.4.2 Responding to capacity strengthening needs

This step involved an assessment of what had been and was being done to strengthen capacity to scale the innovation. Table 6 presents typical examples of efforts by partners to enhance the capacity for scaling the innovation for each of the three cases.

3.4.3 Illustration of navigating capacities to scale the innovation in the three cases

3.4.3.1 Navigating HQCP in widening networks From early on, a community of practice (CoP) was established, including a WhatsApp™-based group ‘Cassava Peel First Movers’ (200 members) who are in virtual contact on all matters regarding cassava peels. Partner-

Table 5 Initial (early 2018) strategic response to diagnosed scaling readiness and related capacity needs

	HQCP	Triple S PLUS	SDSR
Scaling strategy and partnership	A broad-based multi-stakeholder (including private sector) partnership process to put everything in place in all relevant sectors, to enable processing and use of HQCP at scale. Galvanising the public and private sectors to lead scaling. Using social media, including YouTube, to communicate the innovation. Extending knowledge of adopters beyond the production of ingredients to their optimal use in feed composition and commerce	Ethiopia: International non-governmental organisations (INGO) scaling partners, government and CIP research for development (R4D) projects provide entry points through their ongoing agriculture-nutrition programmes, which were promoting OFSP; training of trainers (ToTs); cascades training to Champion Households; multi-media communication strategy; nationwide learning support Ghana: Similar to Ethiopia; also, strong link to on-going OFSP projects	Burundi: Through partnerships with BPEAE (the public agency responsible for agricultural extension) and the Amashiga project (a USAID Food for Peace initiative) using ToTs cascading trainings, farmers are applying SDSR in Muyinga province DRC: Scaling out the Single Diseased Stem Removal package through ToTs cascading trainings accompanied by 'facilitated first cutting of sick plants' in South Kivu through partnerships with INERA, IPAPEL and farmers
Type of partners	Private sector individuals and organisations, NGO, public sector stakeholders in agriculture (livestock & fish) and the environment, government parastatals in research, banking and extension	Initially: large INGO nutrition-sensitive agriculture programmes, government research and extension departments; CIP R4D projects. In Ghana, as large INGO programmes closed, we continued with smaller community-based organisation (CBO) implementing partners and Regional Directorates of Agriculture. We also engaged a private sector seed company to produce and sell planting materials	Government research organisations and extension agencies; NGOs; Farmers; CGIAR Centres

Table 6 Capacity strengthening efforts by partners in scaling

Capability to scale the innovation	Typical (selected) efforts by partners in scaling to improve and/or sustain the scaling initiative
To relate and partner	Triple S PLUS Ethiopia: annual reflection meetings and learning journeys. BoANRD field staff created a WhatsApp group to share successes and challenges Ghana: quarterly meetings; ToT sessions; cross-country; and local innovation platform
To resource and act	SDSR DRC: effectively collaborated with a second but key public sector partner Burundi: the local partner was able to successfully mobilise operations. Quick successes became a matter of pride and resulted in increased commitment and some in-kind contributions of staff time
To adapt and navigate challenges	HQCP The recruitment process for selecting trainees was changed/modified to include a pre-inspection of the business premises by potential trainees. This reduced the number of applicants, but increased the number of people going on to produce HQCP shortly after training (up to 40%)
To balance diversity and coherence among partners	SDSR DRC: targeting farmers was adjusted following realisation that although men traditionally are landowners, they had often migrated away, making women the de facto crop-managers
To make scaling contribute to sustainable development	SDSR Burundi: Wide reach in Muyinga province; clearly visible that SDSR was being applied (no male buds to be seen); expansion of banana plantations was apparent; investment expansion with the introduction of new cultivars (FHIA-commercially sourced)
To anchor the innovation in institutions (to sustain scaling of the innovation)	Triple S PLUS Ghana: intensive collaboration between CIP and Damongo Agricultural College, capacity building of staff and students, and advocacy through a learning journey with key decision makers from the Ministry of Food and Agriculture (MOFA). Incorporation of OFSP and Triple S into the national curriculum Ethiopia: tertiary training institutions incorporated Triple S PLUS into courses. Attractive resource materials in local languages were produced

ship with the Bank of Industry provided options for obtaining credit to set up shop as entrepreneurs. Private sector partners opened their facilities to interested entrepreneurs in their vicinities to be trained to produce HQCP. Active development of partnerships expanded capacity to include the formulation of least-cost balanced rations of animal feed incorporating HQCP products into the FeedCalculator®, a smartphone app that generates least-

cost & high quality feed recipes based on locally available ingredients. This in itself is a driver of production through effective utilisation. Partnership with the ICT unit of IITA was also undertaken regarding the development of the Cassava Peel Tracker®, which has documented more than 1250 sources of cassava peel.

3.4.3.2 Navigating Triple S PLUS amidst a high turnover of partners and other socio-cultural issues Regular training events and quarterly meetings with partners included opportunities for feedback on technical issues. When there were unanticipated shortages in planting material, existing partners stepped in, or new partners were identified, e.g. private sector seed producers. Technical field staff used social media (WhatsApp) to share challenges and solutions. Aligning the project's life cycle with the cropping season was a challenge. This required re-scheduling the training modules to ensure that the Triple S training activities were aligned to the times in the cropping season for the key Triple S steps. The timing of the project cycle had implications for the availability of roots, requiring not previously envisaged additional vine multiplication and dissemination activities. In Ghana, when an INGO scaling partner's large project ended, we continued to work with the smaller community-based organisations that had been implementing partners for the INGO. Partnering with the government extension system and advocacy to prioritise OFSP and Triple S in the annual work plans and budgets at the district level was essential for the medium-term institutionalisation of Triple S and related good agricultural practices.

In Ethiopia, monitoring data showed that the number of women farmers participating in the training and video sessions was much lower than planned. Partners explained that the participation of women is affected by social and cultural perspectives. Several strategies were used to increase the participation of women and encourage the transfer of knowledge from the husband to wife at the household level, e.g. participating women were invited to sit at the front and the Development Agents encouraged the participating men to pass the information on to their wives at home. Another important dynamic to be navigated was the political situation in Ethiopia involving the exclusion and marginalisation of certain groups.

3.4.3.3 Navigating SDSR within governmental and cultural dynamics In Burundi, it was assumed that the buy-in of the public agency responsible for agricultural extension (BPEAE) would naturally filter upwards to national policymakers and that a high-level workshop would be sufficient to 'seal the deal' on new policy for BXW control. However, through the workshop on SDSR in 2019, its integration within national policy became a political exercise rather than a technical one. Government officials were focussed on disease eradication rather than control through cultural management practices; they were also contesting the validity of the approach beyond Muyinga province in which the scaling project worked, emphasising the need for additional projects that would test SDSR in all provinces in liaison with Burundi National research partners.

SDSR is promoted as an *individual* practice because it is not strictly necessary for all farmers in a community to apply it in order for SDSR to be effective. Some communities in DR Congo created local BXW by-laws. This turned BXW control through SDSR into a community-level issue, which made farmers' application of SDSR a grassroots practice.

3.5 Evaluating the effectiveness of capacity in achieving scale, institutionalisation, and development impact

The following provides a selected summary from project documentation illustrating three types of effects gained from applying the C4SI approach in the three cases: (1) The change in scale of use/application of the core innovation; (2) The level of institutionalisation; and (3) Development effects (e.g. employment, income, nutrition and reduced pressure on the environment). No specific C4SI tool was employed here. The summaries are based on monitoring and evaluation of the partners in scaling.

3.5.1 Achieving scale: potential vs. reality

Compared to the original targets, all three scaling projects have been doing well. In total, by mid-2019, the Triple S PLUS project reached¹ 10,081 farmers in Ethiopia and 77,779 farmers in Ghana. Male and female farmers have been reached through different methods of training for Triple S PLUS, including direct demonstration, video-based extension and radio programmes. In Burundi, 19,000 more farmers in Muyinga province now apply SDSR. A recent evaluation showed that 83% of farmers who at one point had BXW in their fields are now applying SDSR and have controlled the disease. As for HQCP, 208,000 YouTube viewers were reached with its promotional five-minute video; more than 250 female and male investors were trained in hands-on processing and linked up with Bank of Industry (BoI) as a credit source.

3.5.2 Institutionalisation of scaling: potential vs. reality

Institutionalisation enables continued scaling beyond the reach of the research organisation. This relates directly to the capability to anchor the innovation within institutions.. In Ghana and Ethiopia, for example, Triple S PLUS has become a standard component of sweet potato R4D projects and has resulted in increased visibility in policy, improved collective technical capacity and the inclusion of more partner organisations in the effort to scale Triple S PLUS. Farmer-to-farmer videos explaining the innovations in local languages have proven to be a training tool that allows quality information to reach a large number of potential beneficiaries. This has laid a stronger foundation to achieve changes at system level, i.e. a resilient root-based seed system versus a vine-based seed system. The latter requires year-round access to water sources, which are threatened by unpredictable weather patterns or a higher investment in irrigation infrastructure. A continent-wide project in Africa (TAAT), funded by the African Development Bank (AfDB), has included Triple S PLUS as one of the technologies to be promoted at scale as part of a vine dissemination project. The project aims to ensure community capacity to maintain and multiply vines and thus ensure sustainability of adoption. In Ethiopia, organisations have adopted it as an exit strategy for their vine dissemination programmes and it is cited as an example of a climate-smart practice in policy documents. In Ghana, the incorporation of OFSP

¹ As defined in the Triple S PLUS proposal: A person reached would be any person who would have (1) been part of a group that has physically tested the technology, (2) attended or participated in an event in which the double S or Triple S technology was presented (this can be a field visit, video viewing or other), and (3) is aware of the double S or Triple S technique through other channels (radio, interaction with neighbours, family members or others).

and Triple S PLUS into the national tertiary agricultural training curriculum has led to the request of additional capacity building from four agricultural colleges. It is expected that new students from the agricultural colleges will have the ability to disseminate innovation packages about OFSP and Triple S PLUS at the request of farmers, processors, seed producers and projects.

In Burundi, a key aim for SDSR is to be integrated into government national policy to control BXW. Although SDSR has not (yet) been officially integrated in national policy, BPEAE is informally using SDSR scaling material in certain provinces, as they know it works.

In Nigeria, the project facilitated the emergence of a community of practice (CoP) platform on HQCP, known as Cassava Peel First Movers (Whatsapp™-based), which has more than 190 active members, including trained potential investors. It is currently transitioning from a Whatsapp CoP into a registered association. The project also developed the Cassava Peel Tracker® app, through which 1,250 cassava peel sources have been identified and geo-referenced in south-west Nigeria. Furthermore, an online FeedCalculator® app was developed to enable feed millers and farmers to formulate least-cost balanced rations incorporating HQCP—more than 800 of these successful feed recipes include HQCP. Federal government extension staff were trained to train interested entrepreneurs in three additional Nigerian states. Finally, four states in southwest Nigeria (Oyo, Ogun, Osun, and Lagos) have expressed an interest in replicating the project's processing demonstration centres to carry on the scaling work.

3.5.3 How scaled innovation contributes to development effects: potential vs. reality

Since direct and indirect effects are still largely emergent due to the short time frame of the scaling projects and for the sake of keeping our summary sufficiently limited, we do not provide details about this here. It is, however, a crucial part of C4SI, since it relates closely to a capability to make scaling work for sustainable development. The fact that Ethiopia's political situation led to the exclusion of certain groups from project (potential) benefits illustrates how effects are not only about the intentions and efforts of the scaling initiative but are also affected by wider context dynamics. Similar contextual conditions were reported, e.g. in the case of Ghana, in relation to gender issues (regarding who benefits and who does not).

4 Discussion

C4SI was developed in response to a need to better understand and strengthen the capacity for navigating challenges in (emerging) partnerships in the three cases of scaling innovations. In the previous section we illustrated what type of insights its application may render. In this section, we discuss the implications and complications of C4SI application in relation to the four main research objectives: *conceptualising* capacity to scale innovations for sustainable development (4.1); *using* C4SI in support of scaling-related management and partnerships (4.2); *learning* about conditions that shape capacity to scale innovations for sustainable development, specifically focusing on the role of research organisations (4.3); and *translating* findings into insights regarding the formation of partnerships for scaling the innovation, where we focus on the contribution of C4SI to a science of scaling (4.4).

4.1 Enhancing conceptual understanding about capacity to scale innovations

In the following, we discuss a number of perspectives on the capacity to scale innovations that emerged from the C4SI development process.

4.1.1 An actor's perspective on scaling

The capability assessments alerted scaling projects to the differences between, and complementarity of, capabilities among partners, and the related roles that different partners can and need to play. From a collective perspective, individual farmers' core contributing capability is that they know exactly which realities the scaling innovation will need to be directed to. Institutionalisation of scaling within organisations is more a capability of the ministries of agriculture and agricultural training institutions, for example. Some partners (such as large NGOs/projects) may temporarily contribute their strong capability to resource and act, whereas others (such as local NGOs, trained Decentralised Vine Multipliers (DVMs) and/or private sector partners) are needed to sustain and grow an activity. This underscores the relevance of a perspective on *collective* capabilities, and this is why we suggest distinguishing between being scaling partners and being *partners in scaling*. The reference to *scaling partners* is more about subcontractors of lead actors, whereas being *partners in scaling* involves more of a co-creative process of scaling an innovation. Being *partners in scaling* is an ideal that may not always be fully achieved due to project arrangements and wider contextual conditions.

Acting together as partners in scaling plays out in a particular context that can be more or less constraining. This makes it difficult to compare the experiences of the scaling projects. If contexts (internal and external) are different, so will be the matching capacity to navigate such contexts, as well as what may be considered a realistic level of what can be achieved. A multi-level perspective on capacity to scale innovations was found to help articulate related dimensions and dynamics.

The reflection on the C4SI application alerted the authors to something that may be framed as the *political economy of partnerships* for scaling innovations. This relates to the role of incentives and interests and wider motivations that are not directly related to making a difference through scaling the innovation, but rather to careers, positions, directives, policies, etc. Thus, in the Triple S PLUS case, continued scaling of Triple S required the capacity to institutionalise Triple S into governmental extension activities, but this was limited by internal prioritisation of resources and changes in power relations. As a result, while BoANRD staff were available to implement the cascade training (ToTs) for Triple S, additional resources to scale Triple S PLUS were limited to contributions from NGOs. We found this political economy of partnerships for scaling to be an important dynamic that played out in all cases, but to which we were insufficiently able to connect. It may help to add some (existing) tools to address the topics of 'user realities', and 'alignment of interests and efforts' to help make more explicit the otherwise tacit stakeholder interests and motivations. If stakeholder motivations are better understood, it is easier to connect to these, or to decide that these realities do not justify further efforts.

4.1.2 A perspective on the role of special individuals

The RTB Scaling Fund provided enhanced opportunities for *facilitating* a process of being partners in scaling through funding, methodological support, a collaborative learning environment and, importantly, the employment of scaling champions. These scaling champions may be compared to innovation brokers or intermediaries (Howells 2006; Katzy et al., 2013; Turnhout et al., 2013), but in relation to the process of scaling innovations. It is time to complement the large body of literature on innovation brokers/intermediaries with studies on the role of scaling brokers/intermediaries (also see Muilerman, 2019; van Paassen et al., 2014; Wigboldus et al., 2016), but before doing so, this special role needs to be put into practice more. The experiences in the RTB Scaling Fund provide initial insights and point to a need to consider how best to select, prepare and train such persons, and how they can be best positioned in research organisations and/or wider initiatives.

As much as the scaling champions were found to play a critical role in being partners in scaling, other champions were found to play a key role as well. They are those individuals in partner organisations who energise partners into playing an active role. They have bought into the idea of helping the innovation go to scale and are able to envision future benefits from application at scale. In that sense, partners are often personified through such organisational champions. The capability to partner for scaling was therefore found to relate to an ability to connect to such champions and maintain good relationships with them. On the downside, if they relocate, the scaling partnership often has a problem, which could point to a lack of institutionalised capacity for scaling.

4.1.3 A systemic and sustainable development perspective on scaling

Adapting the original capability description related to achieving development results (Baser & Morgan, 2008) into a capability to make scaling work for sustainable development helped articulate a more purpose-oriented perspective on scaling innovations (Gargani & McLean, 2017; Jacobs et al., 2018; Woltering et al., 2019). This also involves asking the right (evaluation) questions and a capability to find the right answers to these questions. This is not only about direct effects in terms of, for example, reduced environmental pollution, increased employment opportunities, or enhanced food and nutrition security. It is also about an ability to anticipate possible side effects in other spheres of life, including changed household level dynamics (e.g. involving gender issues), and about enhanced opportunities for new collaborative efforts because of the establishment of relationships as partners in scaling. Therefore, a capability to make scaling contribute to sustainable development includes strong abilities in the field of monitoring and evaluation both intended and unintended, as well as direct and indirect, consequences and implications of scaling innovations.

4.1.4 A temporal perspective on required capabilities

Considering the way in which the need for different capabilities worked out in the three cases shows how they need to play out differently over time in a scaling partnership approach. If this is a correct interpretation, it would underscore the alleged need

(Muilerman et al., 2018) to approach scaling processes as distinctly different from research and innovation projects and therefore understand them as requiring different, or rather, additional capabilities.

4.2 Using C4SI in support of scaling-related management and partnerships

We found C4SI to do more than facilitate the development of capacity perspectives on the scaling initiative. It can support an actor-oriented and integrated approach to engaging with processes of scaling innovations. Figure 2 provides a graphical summary of (ideal type) core processes of the scaling projects and their relation to the capacity for scaling innovations as derived from the experience of exploring capacity perspectives in the three cases. We elaborate on this in the following two subsections.

One of the main challenges in applying C4SI has been its translation into appropriate tools for field staff, so that they benefit from the perspectives it offers and can fully participate in its application. This was partly related to the fact that C4SI was not fully developed at the start of the scaling project; it evolved gradually. In the following we discuss C4SI and its application from several angles.

In its earlier versions, C4SI applications were found to be too complex for scaling project staff (let alone for the wider circle of partners in scaling), though the essential ideas underpinning it were welcomed. This resulted in insufficient consistency in interpretation and application between the cases. For example, in the Triple S PLUS case, in the initial assessment, the dimension around ability to agree among partners was understood as agreement among actors of the same type, rather than agreement across different partners. For many, only after having gone through a number of assessment attempts and having discussed findings did the usefulness of the C4SI perspective become clear. While the C4SI approach was found useful in helping implementers consider the way in which the capabilities of the consortium of partners were playing out, the analyses were not always done in a standardised way and interpretations varied across countries both within one project and between projects. One major question of divergence was whom we consider as partners and whether research organisations were able to objectively assess research organisation capabilities. As mentioned earlier, this was also linked with the later introduction (and evolutionary process) of C4SI in response to capacity issues that each case was facing.

Further development of C4SI may take a number of routes, including simplification, enhanced facilitation, and/or selective application. Simplification may involve using elements from C4SI as checklists only, and may be linked to the option of coarsely scoring capacity metrics in order to make strategic decisions regarding where to invest. Facilitation of the application of C4SI with field staff was only done in a limited way. Making C4SI part of core programming from the start will make it possible to better integrate it into processes (workshop, meetings) where good facilitation can be provided. Selective application would mean using only those elements of C4SI that appear to fit the purpose of a particular scaling project.

4.3 Learning about the role of research organisations in scaling

In each of the cases, a research organisation played an initiating and lead role in the partnership for scaling (cf. Joly et al., 2015; Leeuwis et al., 2018). We found that these organisations are often not sufficiently equipped to play such roles, even though in principle they are well-positioned to do so. Due to reasons such as bureaucratic regulations, they may

Table 7 A critical reflection on the role of research organisations in partnerships for scaling innovations

Reflecting on the role of research organisations in partnerships for scaling innovations		Challenges faced
Capabilities	Current (common) constraining practices	Ideal/Preferable options
Capability to relate and partner in scaling the innovation	Sub-grantee/contract agreements on a project-by-project basis Developing Memoranda of Understanding (MoUs) is a difficult and slow process Crop-specific mandates	Programme/Project collaboration agreement to partner through R4D process Simple templates for MoUs, with minimal legal jargon Agri-food system focus
Capability to resource and act for scaling the innovation	Technical/natural science focus	R4D experience: both technical and soft skills
Capability to adapt and navigate challenges in scaling the innovation	Focus on RBM and deliverables for the donors	Focus on process and joint accountability
Capability to balance diversity and coherence among partners in scaling the innovation	CGIAR first order partner for research activities is the NARI. For scaling this may not be the most appropriate partner	CGIAR and NARs need to engage with government extension departments
Capability to make scaling of the innovation contribute to sustainable development	Crop-specific mandate Slow internalisation of responsibility to achieve development results, beyond mere delivery of innovations	An understanding of responsibility to facilitate scaling process, recognising scaling agenda must be (come) 'owned' across partners in scaling Difficulty in knowing when to handover (exit strategy) Lack of clear mandate for scaling process from management Lack of reward system Discrepancy between institutional performance metrics (e.g. publishing research) with impact narratives/rhetoric

Table 7 (continued)

Reflecting on the role of research organisations in partnerships for scaling innovations		
Capabilities	Current (common) constraining practices	Ideal/Preferable options
Ability to anchor the innovation in institutions for continued scaling of the innovation	Limited reflection on and use of exit strategies as 'handing over responsibility' at the end of a project	Identify and work with power brokers within key institutions—those who have both interest and ability to set the scaling agenda Reflect on the capabilities required to sustain scaling of the innovation
		Challenges faced How to identify 'movers and shakers'? How to build up long-term relationships based on trust and mutual understanding?

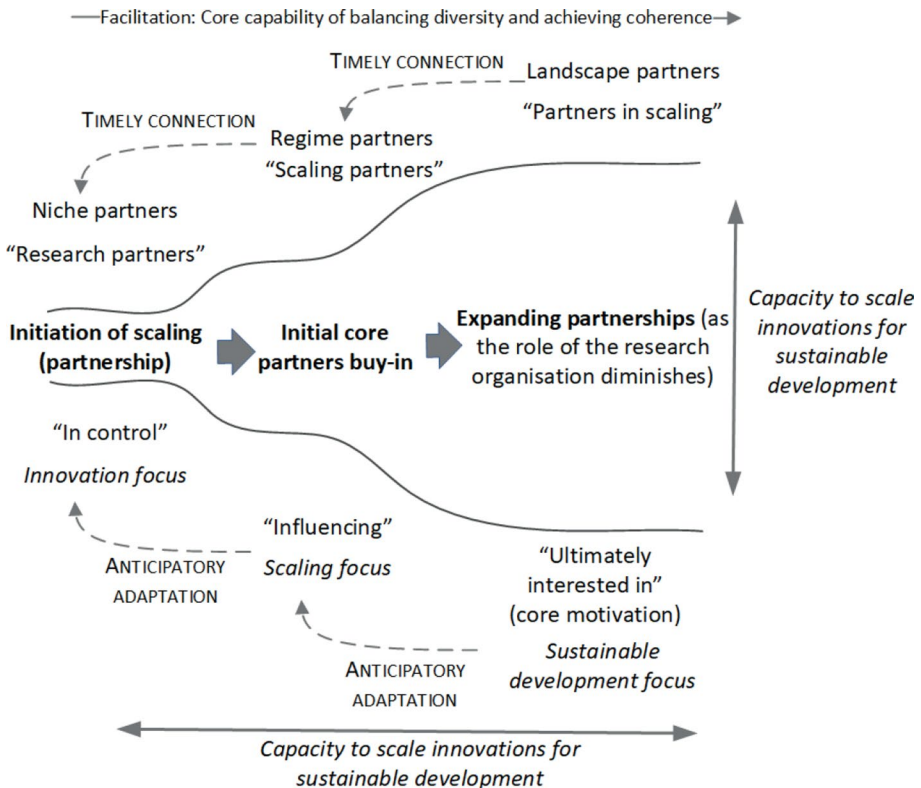


Fig. 3 Graphical summary of (ideal type) core processes involved in (enhancing) the capacity to scale innovations for sustainable development

even disturb the process of becoming partners in scaling, so it is important for research organisations to practice introspection/reflect carefully and consider how they could become a better partner. Table 7 summarises related reflections.

4.4 The contribution of C4SI to a science of scaling

In recent years, several authors have been working towards something called the Science of Scaling (Gargani & McLean, 2017), or Scaling Science (Schut et al., 2020), namely the development of a systematic engagement with processes of scaling innovations that acknowledges the complexities and potential complications involved in such processes. So far, a systematic analysis of the capacities of actors in a scaling partnership has not been put forward. It involves bringing together insights regarding processes of scaling innovations with the wealth of experience gained in general approaches to capacity development (e.g. Baser & Morgan, 2008; Udoh James, 2018) and partnerships (e.g. Horton et al., 2009). We argue that C4SI—in its application of capacity and partnership perspectives and approaches—can contribute to the ‘Science of Scaling’.

Since it incorporates (core) elements from MLP, the five capabilities approach and scaling readiness (illustrated in Fig. 3), C4SI is not really a novel approach, but rather a hybrid one, building on the proven strengths of those approaches. It brings to the fore something

that few (if any) approaches to scaling innovations do: a systematic perspective on capacity issues in the context of scaling partnerships. C4SI offers a language and structure to consider collective capacity issues systematically and meaningfully, connecting to realities that are (at least in part) distinctly different from innovation capacity and capacity of innovation systems (Muilerman et al., 2018). Therefore, though there is an obvious connection to (agricultural) innovation system approaches (Francis et al., 2016; Spielman et al., 2011), it was clear in each of the cases that scaling processes reach beyond innovation systems to include wider societal dynamics. This implies that partners in scaling will include partners that would not otherwise be considered part of the (agricultural) innovation system.

There are also limitations to C4SI. We noted in the introduction that scaling innovations should never become an end in itself, but that this is nevertheless a widespread tendency. As much as CS4SI offers a language and structure to consider capacity issues in the context of scaling innovations systematically and meaningfully, it seems to insufficiently offer a basis for considering how such scaling will contribute to sustainable development by applying principles of responsible innovation and scaling (Wigboldus et al., 2020). It means that C4SI helps to understand collective capacity issues in the context of scaling partnerships but will need to be complemented by other methods and perspectives that shed more light on the way in which the scaling of particular innovations do or do not contribute to wider sustainability transitions (Wigboldus, 2021).

5 Conclusion

In this paper, we have presented C4SI as an approach that aims to help come to grips with the capacity dimensions and the dynamics of challenges faced in partnerships for scaling innovations. We demonstrated C4SI's usefulness in the context of three cases in Africa. The approach evolved in the context of the RTB Scaling Fund, which helped shape conditions for capacity to scale the innovations, and we still consider it to be an approach in development. Though many aspects of C4SI can be considered relevant for wider application, contextualisation in new (project) environments will be needed (cf. Klerkx et al., 2017), notably the definition and selection of capability dimensions.

C4SI was found useful in creating a language and framework for articulating capacity dimensions and dynamics in relation to the scaling projects. It allowed for structured and systematic consideration of relevant issues in sense-making and decision-making processes. It can help to better anticipate challenges and enhance opportunities to prepare as a research organisation and as broader groups of partners in scaling. In case more systematic documentation and comparison is required, we have shown options of how assessment tools can be developed. Thus, it provides opportunities for enriching a science of scaling (Gargani & McLean, 2017; Schut et al., 2020).

Based on the experience of developing, applying, and iteratively adapting C4SI, we have a number of recommendations for those interested in applying a contextualised version elsewhere.

First, since grasping what was behind the thinking underpinning the categories of assessment and their application was found to be demanding for field staff, working with simple checklists and overviews derived from C4SI may in many cases be more appropriate.

Second, it is critical to not just look at capacity for scaling innovations as an end in itself, but to look at the potential for the scaling of the innovation contribute to sustainable

development. This involves activating a perspective on responsible innovation and responsible scaling of innovations (McNaghten et al., 2014; Stilgoe et al., 2013; Wigboldus and Leeuwis 2013; Wigboldus et al., 2016) and strongly hinges on abilities to anticipate implications of envisaged scaling processes and ambitions from early on (cf. Ghiron et al., 2014; Potter & de Wolf, 2014). C4SI does not cover such aspects sufficiently, and it therefore needs to be complemented by methods that are a better match for this.

Third, it is worth pursuing a process of becoming *partners in scaling*, which is different from having a lead organisation supported by scaling partners as subcontractors. This may also be a relevant perspective for innovation platforms (Schut et al., 2016), which otherwise run the risk of being reduced to mere platforms for facilitating the roll-out of pre-designed innovations.

Fourth, some group needs to play the role of coordinating and facilitating the convergence of efforts as partners in scaling (cf. the capability to balance diversity and achieve coherence). Research organisations are in principle well-positioned to play this role, provided they critically consider the internal capabilities that this will require. Being partners in scaling ultimately involves navigating technical, institutional and political challenges, and not every researcher is equipped to engage with such challenges.

Fifth, navigating conditions for scaling requires flexibility as a core capability (a dimension of the capability to adapt and self-renew). It involves timing as well as the ability to wait for the right moment, and the skill of developing and maintaining relationships. Flexibility in funding and wider support mechanisms, or lack of either, is therefore part of what shapes the capacity for scaling innovations.

Acknowledgements This research was undertaken as part of, and funded by, the CGIAR Research Program on Roots, Tubers and Bananas (RTB) and supported by CGIAR Trust Fund contributors. We thank Marc Schut for his helpful comments on an earlier draft. We benefitted from the comments of the anonymous reviewers of an earlier version of the article.

Funding This study was funded by the CGIAR Research Program on Roots, Tubers and Bananas (RTB) and supported by CGIAR Trust Fund contributors.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Adekunle, A., Fatunbi, A. O., & Kefasi, N. (2016). The Theory of Change Underlying the Efficiency of Agricultural Innovation Platforms (IPs): The Case of the Thyolo Vegetable IP in Malawi. In J. Francis, L. Mytelka, A., N. van Huis, & N. Röling (Eds.), *Innovation Systems: Towards Effective Strategies in*

- support of Smallholder Farmers, CTA and WUR (CoS-SIS)* (pp. 143–155). Wageningen: Wageningen University.
- Ajayi, T., Fatunbi, O., & Akinbamijo, Y. (2018). *Strategies for Scaling Agricultural Technologies in Africa*. Accra, Ghana: Forum for Agricultural Research in Africa (FARA).
- Avelino, F., & Wittmayer, J. M. (2015). Shifting power relations in sustainability transitions: A multi-actor perspective. *Journal of Environmental Policy and Planning*, 18, 1–22. <https://doi.org/10.1080/1523908X.2015.1112259>
- Baser, H., & Morgan, P. (2008). *Capacity, change and performance*. Study report. Maastricht, the Netherlands: ECDPM.
- Bebbington, A. (1999). Capitals and capabilities: A framework for analyzing peasant viability rural livelihoods and poverty. *World Development*, 27, 2021–2044. [https://doi.org/10.1016/S0305-750X\(99\)00104-7](https://doi.org/10.1016/S0305-750X(99)00104-7)
- Blok, V., & Lemmens, P. (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 B.J. Koops, L. Oosterlaken, H. Romijn, T. Swierstra, & J. van Hoven (Eds.) *Responsible innovation 2: concepts, approaches and applications* (pp. 19–35). New York: Springer.
- Blesh, J., & Wolf, S. (2014). Transitions to agroecological farming systems in the Mississippi River Basin: toward an integrated socioecological analysis. *Agriculture and Human Values*, 31, 621–635. <https://doi.org/10.1007/s10460-014-9517-3>
- Brouwer, H. & Woodhill, J. (2015). The MSP guide. *How to design and facilitate multi-stakeholder partnerships*. Centre for Development Innovation. Wageningen: Wageningen UR.
- Caplan, K., Gomme, J., Mugabi, J., & Stott, L. (2007). *Assessing Partnership Performance: Understanding the Drivers for Success. Building Partnerships for Development*. London: Building Partnerships for Development (BPDWS).
- Checkland, P., & Scholes, J. (1999). *Soft systems methodology in action*. Chichester, UK: Wiley.
- Chandy, L., & Linn, J. F. (2011). *Taking development activities to scale in fragile and low capacity environments*. Global Economy & Development. Working Paper No. 45. Washington D.C.: The Brookings Institution.
- CIP. (2019). Triple S Technology. Lima: International Potato Center. Retrieved February 26, 2020 from <https://bit.ly/2w2USFc>
- Cleaver, K. (2013). *The importance of scaling up for agricultural and rural development. And a success story from Peru*. IFAD Occasional Paper 4, IFAD, Rome
- Coe, R., Sinclair, F., & Barrios, E. (2014). Scaling up agroforestry requires research ‘in’ rather than ‘for’ development. *Current Opinion in Environmental Sustainability*, 6, 73–77. <https://doi.org/10.1016/j.cosust.2013.10.013>
- Deneulin, S., & Shahani, L. (Eds.). (2009). *An introduction to the Human Development and Capability Approach*. Earthscan.
- Dogliotti, S., García, M. C., Peluffo, S., Dieste, J. P., Pedemonte, A. J., Bacigalupe, G. F., Scarlato, M., Alliaume, F., Alvarez, J., Chiappe, M., & Rossing, W. A. H. (2014). Co-innovation of family farm systems: A systems approach to sustainable agriculture. *Agricultural Systems*, 126, 76–86. <https://doi.org/10.1016/j.agsy.2013.02.009>
- El Bilali, H. (2019). The multi-level perspective in research on sustainability transitions in agriculture and food systems: A systematic review. *Agriculture*, 9, 74. <https://doi.org/10.3390/agriculture9040074>
- Foran, T., Butler, J. R. A., Williams, L. J., Wanjura, W. J., Hall, A., & Carter, L. (2014). Taking complexity in food systems seriously: An interdisciplinary analysis. *World Development*, 61, 85–101. <https://doi.org/10.1016/j.worlddev.2014.03.023>
- Francis, J., Mytelka, L., van Huis, A., & Röling, N. (Eds.). (2016). *Innovation Systems: Towards Effective Strategies in support of Smallholder Farmers, CTA and WUR (CoS-SIS)*. Wageningen: Wageningen University.
- Frake, A. N., & Messina, J. P. (2018). Toward a common ontology of scaling up in development. *Sustainability*, 10, 835. <https://doi.org/10.3390/su10030835>
- Garb, Y., & Friedlander, L. (2014). From transfer to translation: Using systemic understandings of technology to understand drip irrigation uptake. *Agricultural Systems*, 128, 13–24. <https://doi.org/10.1016/j.agsy.2014.04.003>
- Gargani, J. & McLean, R. (2017). Scaling science. *Stanford Social Innovation Review*, Fall 2017. Stanford, USA: Stanford University.
- Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy*, 31, 1257–1274. [https://doi.org/10.1016/S0048-7333\(02\)00062-8](https://doi.org/10.1016/S0048-7333(02)00062-8)

- Ghiron, L., Shilling, L., Kabiswa, C., Ogonda, G., Omimo, A., Ntabona, A., & Fajans, P. (2014). Beginning with sustainable scale up in mind: Initial results from a population, health and environment project in East Africa. *Reproductive Health Matters*, 22(43), 84–92. [https://doi.org/10.1016/S0968-8080\(14\)43761-3](https://doi.org/10.1016/S0968-8080(14)43761-3)
- Hinrichs, C. C. (2014). Transition to sustainability: A change in thinking about food systems change? *Agriculture and Human Values*, 31, 143–155. <https://doi.org/10.1007/s10460-014-9479-5>
- Hermans, F., Stuiver, M., Beers, P. J., & Kok, K. (2013). The distribution of roles and functions for upscaling and outscaling innovations in agricultural innovation systems. *Agricultural Systems*, 115, 117–128. <https://doi.org/10.1016/j.agsy.2012.09.006>
- Horton, D., Prain, G., & Thiele, G. (2009). *Perspectives on partnership: A literature review*. Lima, Peru: International Potato Center (CIP).
- Howells, J. (2006). Intermediation and the role of intermediaries in innovation. *Research Policy*, 35, 715–728. <https://doi.org/10.1016/j.respol.2006.03.005>
- Huisman, P., & Ruijschoot, L. (2013). Using the Five Capabilities (5C) model: Making a virtue of necessity. *Development in Practice*, 23, 299–311. <https://doi.org/10.1080/09614524.2013.772122>
- Jacobs, F., Ubels, J., & Woltering, L. (2018). *The Scaling Scan- A practical tool to determine the strengths and weaknesses of your scaling ambition*. The Hague: PPPlab, and Mexico: CIMMYT.
- Joly, P. B., Gaunand, A., Colinet, L., Larédo, P., Lemarié, S., & Matt, M. (2015). ASIRPA: A comprehensive theory-based approach to assessing the societal impacts of a research organization. *Research Evaluation*, 24, 440–453. <https://doi.org/10.1093/reseval/rvv015>
- Jonasova, M., & Cooke, S. (2012). *Thinking systemically about scaling up: Developing guidance for scaling up World Bank supported agriculture and rural development operations*. Washington, DC: The World Bank.
- Katzy, B., Turgut, E., Holzmann, T., & Sailer, K. (2013). Innovation intermediaries: a process view on open innovation coordination. *Technology Analysis & Strategic Management*, 25(3), 295–309. <https://doi.org/10.1080/09537325.2013.764982>
- Keijzer, N., Spierings, E., Phlix, G., & Fowler, A. (2011). *Bringing the invisible into perspective: Reference document for using the 5Cs framework to plan, monitor and evaluate capacity and results of capacity development processes*. Maastricht, The Netherlands: European Centre for Development Policy Management.
- Kilelu, C. W., Klerkx, L., & Leeuwis, C. (2013). Unravelling the role of innovation platforms in supporting co-evolution of innovation: Contributions and tensions in a smallholder dairy development programme. *Agricultural Systems*, 118, 65–77. <https://doi.org/10.1016/j.agsy.2013.03.003>
- Klerkx, L., Schut, M., Leeuwis, C., & Kilelu, C. (2012). Advances in knowledge brokering in the agricultural sector: Towards innovation system facilitation. *IDS Bulletin*, 44(5), 53–60.
- Klerkx, L., Seunke, P., de Wolf, P., & Rossing, W. A. H. (2017). Replication and translation of co-innovation: The influence of institutional context in large international participatory research projects. *Land Use Policy*, 61, 276–292.
- Latimer, C. (2013). *UNICEF India Country Office Guidelines on Piloting and scaling up of innovations and good practices*. New Delhi: UNICEF.
- Leach, M., Rockström, J., Raskin, P., Scoones, I., Stirling, A. C., Smith, A., Thompson, J., Millstone, E., Ely, A., Arond, E., Folke, C., & Olsson, P. (2012). Transforming innovation for sustainability. *Ecology and Society*, 17, 11. <https://doi.org/10.5751/ES-04933-170211>
- Leeuwis, C., Klerkx, L., & Schut, M. (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>
- Little, M. (2012). *How to achieve lasting impact at scale. synthesis and summary*. Dartington, UK: Social Research Unit.
- Matt, M., Gaunand, A., Joly, P. B., & Colinet, L. (2017). Opening the black box of impact – Ideal-type impact pathways in a public agricultural research organization. *Research Policy*, 46, 207–218. <https://doi.org/10.1016/j.respol.2016.09.016>
- McEwan, M. A., van Mourik, T. A., Hundayehu, M. C., Asfaw, F., Namanda, S., Suleman, I., Mayanja, S., Imoro, S., & Etwire, P. M. (2022). Securing sweetpotato planting material for farmers in dry-land Africa: Gender-responsive communication approaches to scale Triple S. In G. Thiele, M. Friedmann, H. Campos, V. Polar, & J. W. Bentley (Eds.), *Root, Tuber and Banana Food System Innovations* (pp. 353–388). Cham, Switzerland: Springer.
- McNaghten, P., Owen, R., Stilgoe, J., Wynne, B., Azevedo, A., de Campos, A., Chilvers, J., Dagnino, R., di Giulio, G., Frow, E., Garvey, B., Groves, C., Hartley, S., Knobel, M., Kobayashi, E., Lehtonen, M., Lezaun, J., Mello, L., Monteiro, M., ... Velho, L. (2014). Responsible innovation across borders:

- Tensions, paradoxes and possibilities. *Journal of Responsible Innovation*, 1, 191–199. <https://doi.org/10.1080/23299460.2014.922249>
- Morrissey, J. E., Miroso, M., & Abbott, M. (2014). Identifying transition capacity for agri-food regimes: Application of the multi-level perspective for strategic mapping. *Journal of Environmental Policy & Planning*, 16, 281–301. <https://doi.org/10.1080/1523908X.2013.845521>
- Muilerman, S., Wigboldus, S., & Leeuwis, C. (2018). Scaling and institutionalization within agricultural innovation systems: The case of cocoa farmer field schools in Cameroon. *International Journal of Agricultural Sustainability*, 16, 167–186. <https://doi.org/10.1080/14735903.2018.1440469>
- Muilerman, S. (2019). *Innovating service delivery and aligning with the State. The co-creation of scaling mechanisms for cocoa extension in Africa*. PhD dissertation, Wageningen: Wageningen University & Research.
- Namanda, S., Amour, R., & Gibson, R. W. (2013). The Triple S Method of Producing Sweet Potato Planting Material for Areas in Africa with Long Dry Seasons. *Journal of Crop Improvement*, 27(1), 67–84. <https://doi.org/10.1080/15427528.2012.727376>
- OECD (Organisation for Economic Co-operation and Development) (2006). *The Challenge of Capacity Development: Working Towards Good Practice*. DAC Guidelines and Reference Series. Paris: OECD.
- Okike, I., Wigboldus, S., Samireddipalle, A., Naziri, D., Adesehinwa, A. O. K., Adejoh, V. A., Amole, T., Bordoloi, S., & Kulakow, P. (2022). Turning waste to wealth: Harnessing the potential of cassava peels for nutritious animal feed. In G. Thiele, M. Friedmann, H. Campos, V. Polar, & J. W. Bentley (Eds.), *Root, Tuber and Banana Food System Innovations* (pp. 173–206). Cham, Switzerland: Springer.
- Open African Innovation Research (Open AIR). (2020). Scaling innovation: How open collaborative models help scale Africa's knowledge-based enterprises. Open AIR network, Cairo, Cape Town, Johannesburg, Lagos, Nairobi and Ottawa.
- Potters, J., & de Wolf, P. (2014). It is never too soon to think about scaling. Scaling integrated Pest Management in Denmark. In J. van den Berg (Ed.), *Blowing the seeds of innovation: How scaling unfolds in innovation processes towards food security and sustainable agriculture* (pp. 8–9). Wageningen: Wageningen UR.
- Reid, W. V., Chen, D., Goldfarb, L., Hackmann, H., Lee, Y. T., Mokhele, K., Ostrom, E., Raivio, K., Rockström, J., Schellnhuber, H. J., & Whyte, A. (2010). Earth system science for global sustainability: Grand challenges. *Science*, 330, 916–917. <https://doi.org/10.1126/science.1196263>
- Sartas, M., Schut, M., & Leeuwis, C. (2017). *Scaling Readiness for Agricultural Innovations Fundamentals and Metrics. Presentation at Scaling Readiness and Scaling Strategy Development Workshop for African Cassava Agronomy Initiative (ACAI)*, Ibadan, Nigeria: International Institute of Tropical Agriculture, and Wageningen: Wageningen University. <https://doi.org/10.13140/RG.2.2.27993.52324>
- Sartas, M., Schut, M., van Schagen, B., Thiele, G., Proietti, C., & Leeuwis, C. (2020a). *Scaling readiness: Concepts, practices, and implementation*. Lima, Peru: International Potato Center on behalf of RTB.
- Sartas, S., Schut, M., Proietti, C., Thiele, G., & Leeuwis, C. (2020b). 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>
- Schut, M., Klerkx, L., Sartas, M., Lamers, D., Mc Campbell, M., Ogonna, I., & Leeuwis, C. (2016). Innovation platforms: Experiences with their institutional embedding in agricultural research for development. *Experimental Agriculture*, 52, 537–561. <https://doi.org/10.1017/S001447971500023X>
- Schut, M., Leeuwis, C., & Thiele, G. (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>
- Spielman, D., Davis, K., Negash, M., & Ayele, G. (2011). Rural innovation systems and networks: Findings from a study of Ethiopian smallholders. *Agriculture and Human Values*, 28, 195–212. <https://doi.org/10.1007/s10460-010-9273-y>
- Stilgoe, J., Owen, R., & McNaghten, P. (2013). Developing a framework for responsible innovation. *Research Policy*, 42, 1568–1580. <https://doi.org/10.1016/j.respol.2013.05.008>
- Totin, E., van Mierlo, B., & Klerkx, L. (2020). Scaling practices within agricultural innovation platforms: Between pushing and pulling. *Agricultural Systems*, 179, 102764. <https://doi.org/10.1016/j.agsy.2019.102764>
- Turnhout, E., Stuver, M., Klostermann, J., Harms, B., & Leeuwis, C. (2013). New roles of science in society: Different repertoires of knowledge brokering. *Science and Public Policy*, 40, 354–365. <https://doi.org/10.1093/scipol/scs114>
- Udoh James, V. (Ed.). (2018). *Capacity Building for Sustainable Development*. CABI.

- UNDP. (2013). Guidance note. Scaling up development programmes. United Nations Development Programme.
- USAID (2014). *Scaling up the Adoption and Use of Agricultural Technologies*. Global Learning and Evidence Exchange, Bangkok, Thailand 2014. Washington D.C.: USAID.
- Van Oosten, C., Runhaar, R., & Arts, B. (2021). Capable to govern landscape restoration? Exploring landscape governance capabilities, based on literature and stakeholder perceptions. *Land Use Policy*, *104*, 104020. <https://doi.org/10.1016/j.landusepol.2019.05.039>
- van Paassen, A., Klerkx, L., Adu-Acheampong, R., Adjei-Nsiah, S., & Zannoue, E. (2014). Agricultural innovation platforms in West Africa: How does strategic institutional entrepreneurship unfold in different value chain contexts? *Outlook on Agriculture*, *43*, 193–200. <https://doi.org/10.5367/oa.2014.0178>
- Von Schomberg, R. (2013). A vision of responsible innovation. In R. Owen, M. Heintz, & J. Bessant (Eds.), *Responsible Innovation* (pp. 51–74). London: John Wiley.
- Wigboldus, S. (2018). To scale or not to scale – that is not the only question. Rethinking the idea and practice of scaling innovations for development and progress. PhD thesis. Wageningen: Wageningen University & Research.
- Wigboldus, S., & Leeuwis, C. (2013). *Toward responsible scaling up and out in agricultural development. An exploration of concepts and principles*. Wageningen: Centre for Development Innovation, and the Knowledge, Technology and Innovation group.
- Wigboldus, S., Klerkx, L., Leeuwis, C., Schut, M., Muilerman, S., & Jochemsen, H. (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, S., Klerkx, L., & Leeuwis, C. (2020). Making Scale Work for Sustainable Development. A Framework for Responsible Scaling of Agricultural Innovations. In A.A. Adenle, M.R. Chertow, E.H.M. Moors, & D.J. Pannell (Eds.), *Science, Technology, and Innovation for Sustainable Development Goals: Insights from Agriculture, Health, Environment, and Energy* (pp. 518–543). Oxford: Oxford University Press.
- Wigboldus, S.A., van Eldik, Z.C.S., & Vernooij, D.M. (2021). *Transition pathways and transitions to sustainability: A critical exploration of perspectives, typologies and agendas*. Stichting Wageningen Research, Wageningen Plant Research (WPR), Business unit Field Crops. <https://doi.org/10.18174/559148>
- Woltering, L., Fehlenberg, K., Gerard, B., Ubels, J., & Cooley, L. (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>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Authors and Affiliations

S. Wigboldus¹  · M. A. McEwan² · B. van Schagen³ · I. Okike⁴ · T. A. van Mourik³ · A. Rietveld⁵ · T. Amole⁶ · F. Asfaw⁷ · M. C. Hundayehu⁷ · F. Iradukunda⁸ · P. Kulakow⁴ · S. Namanda⁹ · I. Suleman¹⁰ · B. R. Wimba¹¹

M. A. McEwan
M.McEwan@cgiar.org

B. van Schagen
b.v.schagen@kit.nl

I. Okike
i.okike@cgiar.org

T. A. van Mourik
t.v.mourik@kit.nl

A. Rietveld
a.rietveld@cgiar.org

T. Amole
T.Amole@cgiar.org

F. Asfaw
F.Asfaw@cgiar.org

M. C. Hundayehu
M.Chernet@cgiar.org

F. Iradukunda
F.Iradukunda@cgiar.org

P. Kulakow
P.Kulakow@cgiar.org

S. Namanda
S.Namanda@cgiar.org

I. Suleman
Issahaq.Suleman@cgiar.org

B. R. Wimba
b.wimbabenj@gmail.com

- ¹ Wageningen Plant Research, Wageningen University & Research, Wageningen, The Netherlands
- ² International Potato Center, (CIP) Sub-Regional Office, Nairobi, Kenya
- ³ Royal Tropical Institute, Amsterdam, The Netherlands
- ⁴ International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria
- ⁵ The Alliance of Bioversity International and CIAT, Kampala, Uganda
- ⁶ International Livestock Research Institute (ILRI), Ibadan, Nigeria
- ⁷ International Potato Center, Hawassa, Ethiopia
- ⁸ The Alliance of Bioversity International and CIAT, Bujumbura, Burundi
- ⁹ International Potato Center (CIP), Kampala, Uganda
- ¹⁰ International Potato Center (CIP), Tamale, Ghana
- ¹¹ Institut National Pour l'Etude et la Recherche Agronomique (INERA), Mulungu, South Kivu, Democratic Republic of the Congo