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A guide to scaling Resource Recovery & Reuse (RRR) business innovations in Africa and Asia

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Key messages

1. Scaling Readiness appears to be a good fit if combined, for example, with the 'balanced readiness assessment' to capture the investment climate including in- and output markets as well as regulatory, social and institutional readiness levels for the scaling of already empirically tested RRR business innovations.
2. The Scaling Assessment Map offers a business planning tool to support the next steps from pilots to real-life implementation.
3. Of particular importance in the RRR sector are scaling incentives or barriers to the safe use of originally harmful waste resources.
4. Any scaling ambition has to be based on a plausible Theory of Change (ToC) and related Impact Pathways (IP), once the scaling readiness has been confirmed. There are practical tools for assessing the enabling environment, including tested feasibility study frameworks for RRR.
5. Integrated frameworks combining scaling readiness, ToC, and IPs are needed, but should remain innovation-specific, to avoid becoming abstract and too academic in trying to capture the complexity of innovations types, business models and enabling environments.

Objective: To identify the application potential of known scaling frameworks to the innovation package offered by IWMI's Resource Recovery and Reuse (RRR) program, which has extracted technologies and business models with high adaptation potential in the Global South from successful RRR enterprises, and offered related curricula, policy and investment climate analyses.

Context: Domestic waste is a continuously increasing urbanization challenge. The largest waste fractions are organic (e.g. food) waste and wastewater. Given their significant potential for resource recovery, circular business models are in demand. Over the last decade, researchers with the International Water Management Institute (IWMI) have developed, tested and implemented a variety of RRR technologies and business models that simultaneously reduce the waste burden and support the return of resources like crop nutrients, biosolids and reclaimed water to agricultural production.

Background on RRR solutions: Since 2012, IWMI has conducted an RRR program which, across the Global South, analyzed existing and successful enterprises and public-private partnerships (PPPs) for their business models. During this period, over 70 models have emerged, mostly related to fecal sludge, wastewater and solid waste management at suburb or city scales for the recovery of water, nutrient, biosolids and energy. In collaboration with start-up and business schools the models were described using the business model canvas, with additional emphasis on social and environmental benefits and costs, given the inherent health risks of waste management. Several models were tested via feasibility studies in different countries and also implemented through new PPPs.

Innovation scaling and scaling readiness?

IWMI developed business innovations aim at development partners, and public and private entities, to initiate transformative change at the urban level, while the agricultural and public health sectors are ultimate beneficiaries.

This approach differed from many other CGIAR innovations which target farm-level technologies, resources or other inputs directly used by farmers.

For further out- and upscaling, critical questions for the RRR program are, which business models are ready for scaling in which context, and what are the key national and regional investment opportunities and barriers that need to be addressed?

> *"Scalability is the potential of a particular innovation or change to be expanded, adapted or replicated. Although it is easy to define scalability in theory, the meaning in terms of practice is broader and more diverse. Scaling science focuses on impacts."*
>
> Holcombe 2012.

Scaling usually refers to the adaptation, updating and use of innovations such as practices, technologies and market mechanisms, ideally supported by policy arrangements, to reach broader communities of actors and/or geographies.

In relation to its multidimensional character, scaling innovation includes the simultaneous processes of upscaling, outscaling and downscaling (Figure 1).

Outscaling refers to the replication of an innovation within the same or similar locations. For instance, if successful compost stations are set up in more cities, we observe outscaling. When their business approach becomes part of national curricula and fertilizer subsidy programs, it has an increased potential for **upscaling**. Outscaling and upscaling are interdependent.

An increasing production of organic waste compost might result in less use of other fertilizers, i.e. up- and out-scaling are often accompanied by **downscaling**.

Downscaling can be an important, and sometimes unintended [market] response to the scaling of an innovation. In the field of RRR, the scaling of biogas projects in one location resulted in competition for organic waste inputs to the disadvantage of the local compost station. Such possible trade-offs should not be overlooked.

Finally, **deep scaling** refers to impacting cultural roots, like beliefs and norms (Moore et al. 2015).

> *"Any configuration of scaling …. is acceptable if it improves impacts in meaningful ways. Scaling impact implies putting people and the environment first. What matters when scaling is the positive impact the innovation creates for people and the environment."*
>
> McLean and Gargani 2019.

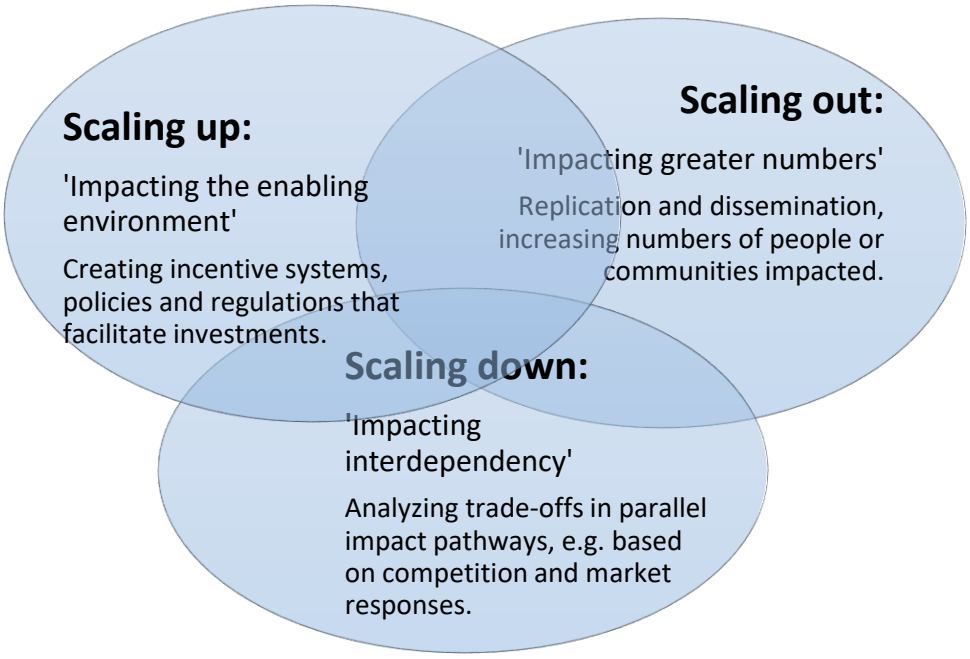


Figure 1**:** Interlinked scaling types (modified from Mclean and Gargani 2019; Moore et al. 2015) without deep scaling.

Benefits of scaling RRR businesses

Most wastewater and organic waste treatment technologies used in the global south rely on nature-based solutions, such as sedimentation and filtration, or composting. These processes have low energy demands while reducing the amounts of waste, offering employment opportunities and providing a reuse-based income stream incentivizing waste collection and treatment which has positive impacts on human and environmental health, including less greenhouse gas emissions from landfills. While farm-based composting has a long tradition in many regions, urban centers are becoming vast sinks of organic waste (food waste and fecal sludge) which call for business interventions at scale towards a circular economy.

The RRR innovation package

The IWMI research group extracted over 70 business models on waste management and reduction (34%), as well as water, nutrient, biosolids and energy recovery (66%)[1] from empirical RRR businesses and initiatives and implemented concomitant award-winning[2] PPPs.

The group also tested and verified RRR technology options, developed and applied methodologies for analyzing the enabling regulatory and financial environment, supported sanitation and waste reuse policies and standards, influenced a national fertilizer subsidy program, and developed RRR curricula which were adopted by a range of universities (Sally and Merrey 2019).

[1] See Otoo and Drechsel 2018; and https://wle.cgiar.org/report-series

[2] https://wle.cgiar.org/iwmi%E2%80%99s-wastewater-aquaculture-reuse-project-wins-sanitation-challenge-ghana

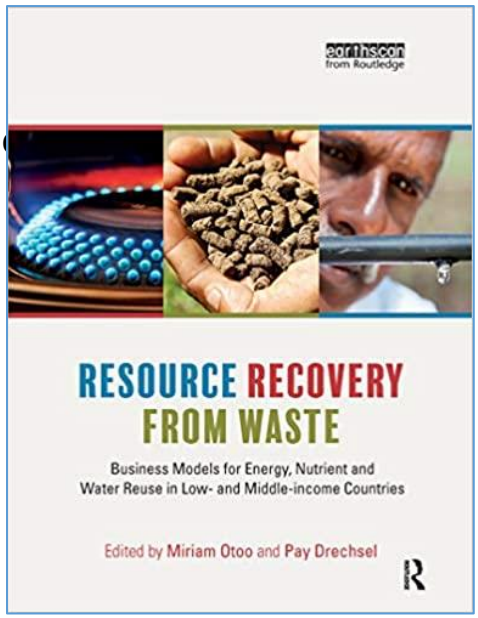
A good look in the mirror—
Are the RRR business models ready for scaling?

Scaling readiness is centered on the ambition to assess the readiness of innovations to achieve specific impact at scale, within a specific user context, and develop, implement and monitor scaling strategies to achieve those scaling objectives. The notion of 'readiness' refers to whether an innovation has been tested and validated for the role it is intended to play in society. Once an innovation is considered ready (like most of the empirically derived RRR business models should be), its actual transfer or replication in a new environment or country requires a broader scaling framework and an analysis of how and why this is expected to happen; this means a presentation of all assumptions i.e. a Theory of Change (ToC).

As there are many scaling frameworks for all types of innovation (bundles), this review tried to identify a good fit for IWMI's RRR business models and their technologies, to assess their potential for scaling up or out, in particular in Africa and Asia, and the Middle East.

A practical scaling framework offers a systematic way to formulate a response. At their best, frameworks simplify what is complex in ways that are actionable. Even though they have some limitations, a highly structured framework might even help to identify, understand, undertake and evaluate scaling. On the other hand, complex frameworks can easily become theoretical, such as introducing new terminology with usually four to seven pillars, principles, steps and so forth. while losing out on practical application.

In total, this review looked at 24 scaling frameworks for the assessment (Appendix 1), guided by the CGIAR context and appropriateness of the scale for IWMI-promoted RRR businesses.



A key consideration for the selection of a framework should be a system perspective for capturing a set of criteria.

Frameworks differ in their applicability depending on the type of innovation to be scaled. A similar comparative assessment of scaling frameworks was published by Dror and Wu (2020) for innovations developed by The International Livestock Research Institute (ILRI) of the CGIAR.

Based on Otoo et al. (2016) and the criteria that other researchers have used to assess innovations in the wider CGIAR contexts, it was deemed that the following set is appropriate for this assessment: Applicability, functionality, operational feasibility, enabling environment, risks and business modeling (Table 1).

Criteria	Assessment components
Applicability	• Evaluate how well the framework can be applied to RRR businesses and related innovations or innovation packages • Applicability within the CGIAR contexts (global south) and to innovation-specific stakeholder groups
Functionality	• Ability to identify a specific scaling pathway • Evaluate the status of the technology or innovation that will be going through the scaling assessment • Review the enabling environment for scaling or provide the basis for portfolio management (readiness of different research projects or stages)
Operational feasibility	• Estimate the level of required time, data and resources needed
Enabling environment	• Ability to evaluate the larger environment where scaling will take place and provide how social acceptance, regulations and institutional environments might affect the scaling process and results, for example
Risks	• The possibility that an innovation fails to achieve desirable impacts, juxtaposed by the possibility that it produces environmental or health impacts that are not desirable • The possibility that trade-offs are amplified through scaling
Business model	• Is the developed framework based on sound business model concepts with due attention to the value proposition, in- and output markets, finance and so forth

Table 1: Criteria for framework analysis (modified from Dror and Wu 2020: Vik et al. 2021: Gabriel 2014).

Based on the analysis, several frameworks, tools and approaches were able to address certain criteria well, but not others as visualized for selected frameworks in Figure 2. Three of these will be presented briefly in the following section:

Scaling Readiness (based on the Technology Readiness Level [TRL]), Balanced Readiness Level Assessment (BRLa) and the Scaling Assessment Map (SAM) tool.

For comparison, ILRI prioritized the scaling scan, scaling readiness and the agricultural scalability assessment tool (ASAT) as appropriate for the ILRI/CGIAR context.

The reasons were their focus on assessing agricultural innovations; conceptually they are relatively well-developed with supporting documentation and tools, and have feasible workload and resource demands (Dror and Wu 2020).

It is obviously difficult to develop or identify a framework that can fit all shoes and still remain practical. Weber et al. (2012), to give an example, identified 157 key drivers for scalability of social enterprises and nonprofit organizations (which the authors could condense into nine clusters) and 93 scaling strategies.

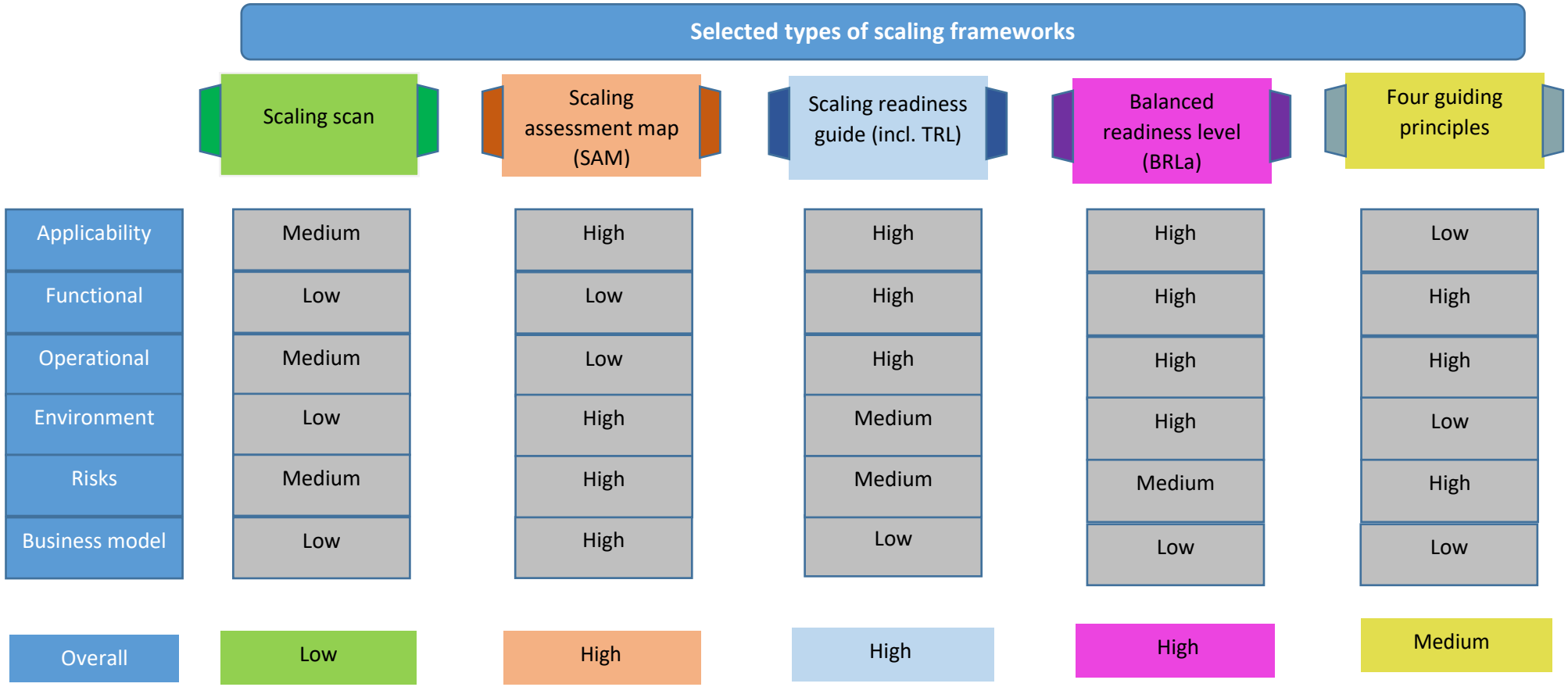


Figure 2: Summary assessment of different selected scaling frameworks.

a) Technology Readiness Level (TRL)

The most popular tool to assess innovation readiness is the Technology Readiness Level (TRL),[3] which most recently Sartas et al. (2020) adapted for use within the CGIAR context where it is increasingly being promoted. The conceptual measurement tool estimates in its core technological maturity on a scale ranging from idea to functional product. The framework is simple and straightforward to apply because it reduces complexity of the innovation into a single metric indicator that can equally be used to assess scalability of the technologies in a broader sense. The TRL usually consists of 7 to 10 levels, as shown in Table 2.

TRL 1	Is a situation where a specific technological idea is formulated
TRL 2	Is when the idea is explicitly described and validated
TRL 3	Is when experimental proofs of concept plans are produced
TRL 4	Is when the elementary technology has been tested and validated in the laboratory and/or simulated environments
TRL 5	Is when the technology is tested in a relevant environment
TRL 6	Is the technology demonstration to stakeholders in relevant environments
TRL 7	Is when a prototype is being tested under controlled conditions in a natural environment
TRL 8	Is when the product has been finally tested, validated and the functionality is being optimized
TRL 9	Is when the actual system is being transferred to an uncontrolled environment and proved functional in use

Table 2: Example of Technology Readiness Levels (modified from Sartas et al. 2020; Vik et al. 2021; Dent and Pettit 2011).

The TRLs will be important for assessing RRR technology adaptation and the preliminary readiness of new business innovations. However, for the further adoption and scaling of already established RRR technologies (like co-composting) or already running RRR business innovations, actual outscaling will depend on factors like input and output markets, financial planning, competition, etc. and the enabling financial and regulatory environment for upscaling.

[3] The concept resonates with levels of technology readiness that have been proposed by the National Aeronautics and Space Administration (NASA) of the United States, the European Commission (EU) and other studies on advancements in technology development, commercialization and transition pathways (Sartas et al. 2020).

Another example of an important factor especially for RRR innovations are regulatory barriers preventing the agricultural use of waste-derived resources. A related key criterion for scaling will be risk management safeguards to protect human and environmental health. Otoo et al. (2016) provided a multicriteria analysis with relevant key indicators and questions around seven pillars to assess the feasibility of RRR business models within a new context.

The close involvement of users and their networks is a component of this (Sartas et al. 2020; Schuetz et al. 2017).

Thus, for RRR business solutions, the TRL as well as Scaling Readiness approaches should be extended to better cover market, regulatory, social and institutional readiness (incentives and barriers) to capture the RRR investment climate (Li and Kassem 2019; Kobos et al. 2018; Dent and Pettit 2011).

An alternative framework that better addresses these additional criteria is the Balanced Readiness Level Assessment (Vik et al. 2021).

b) Balanced Readiness Level Assessment (BRLa)

The BRLa links five dimensions of a technology's readiness together. This gives an overall assessment of a product's development and scaling potential, i.e. where to expect eventual barriers, and where the technology developers or implementers need to focus their attention.

The five dimension of readiness are:
(1) TRL – technology readiness level;
(2) MRL – market readiness level (commodification of a technology);
(3) RRL – regulatory readiness level (legalization of a product);
(4) ARL – acceptance readiness level (legitimization of a new product or technology);
(5) ORL – organizational readiness/ institutional level (like the degree of compatibility the new technology has with existing technologies and capacities).

The framework builds upon a nine-point scale, along those five readiness dimensions (Appendix 1) which can be summarized in a spider diagram. For each readiness scale, the methodology includes a numeric readiness level, a general description of what the level means, and implications in practical terms. The framework also comes with a questionnaire to ease the categorization of actual innovation and derived products, but remains subjective otherwise.

A more detailed analytical framework to diagnose and prioritize interventions for enhancing the scalability of an intervention within a country or region was developed by Izzi et al. (2021) for farmer-led irrigation. Also this analysis can be summarized in a spider diagram (Figure 3) which ranks on its upper half the justification for the innovation and in its lower half the relative strength or weaknesses of the enabling environment, similar to the BRLa.

A low score in the bottom part calls for supporting interventions while a high score allows for focus on efforts elsewhere rather than changing an autonomous dynamic which might be working.

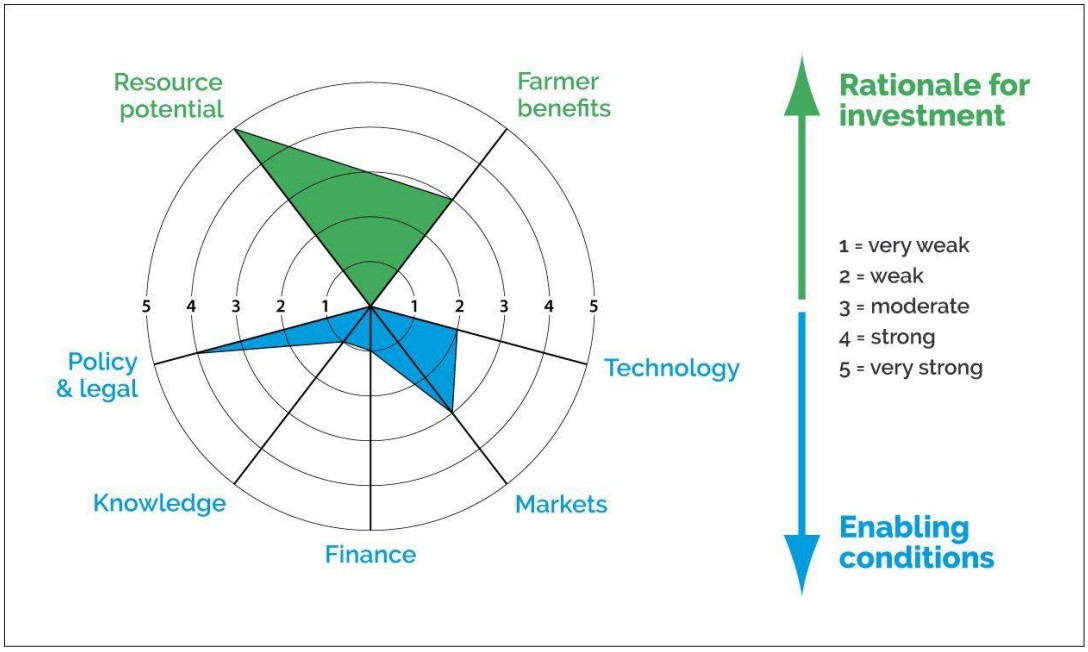


Figure 3: Spider diagram to assess the enabling environment for farmer-led irrigation innovations (Izzi et al. 2021).

c) Scaling Assessment Map (SAM)

The Scaling Assessment Map (SAM) is a working tool for innovation scale up by filling the gap between piloting and real life in the innovation lifecycle, and already useful from level 7 on, in the above example of the Technology Readiness scale.

Ian Gray and Dan McClure developed the tool to support the evaluation and planning for pilot innovation programs to reach the goal of replication and optimization in multiple contexts. The map is a template (Figure 4) similar to a business model canvas[4] that allows the innovation team to continuously improve the scaling model (including both business and financial models) throughout the planning stage. It provides a detailed framework to think about the components of a feasible scaling plan with logistics and support from the outside environment.

It is most suitable for commercial products with social missions in a more business-oriented environment, i.e. the map should ideally accompany actual business plans.

This framework is appropriate to scale innovative business models, also in the waste or sanitation sector, covering risks and financial aspects of the post-pilot stage of an innovation.

Most of the other reviewed frameworks lack the financial criteria and business principles of scaling an innovation.

Users of the SAM framework will however have to adopt or develop a metric to assess the readiness of their innovations.

[4] https://www.strategyzer.com/canvas/business-model-canvas

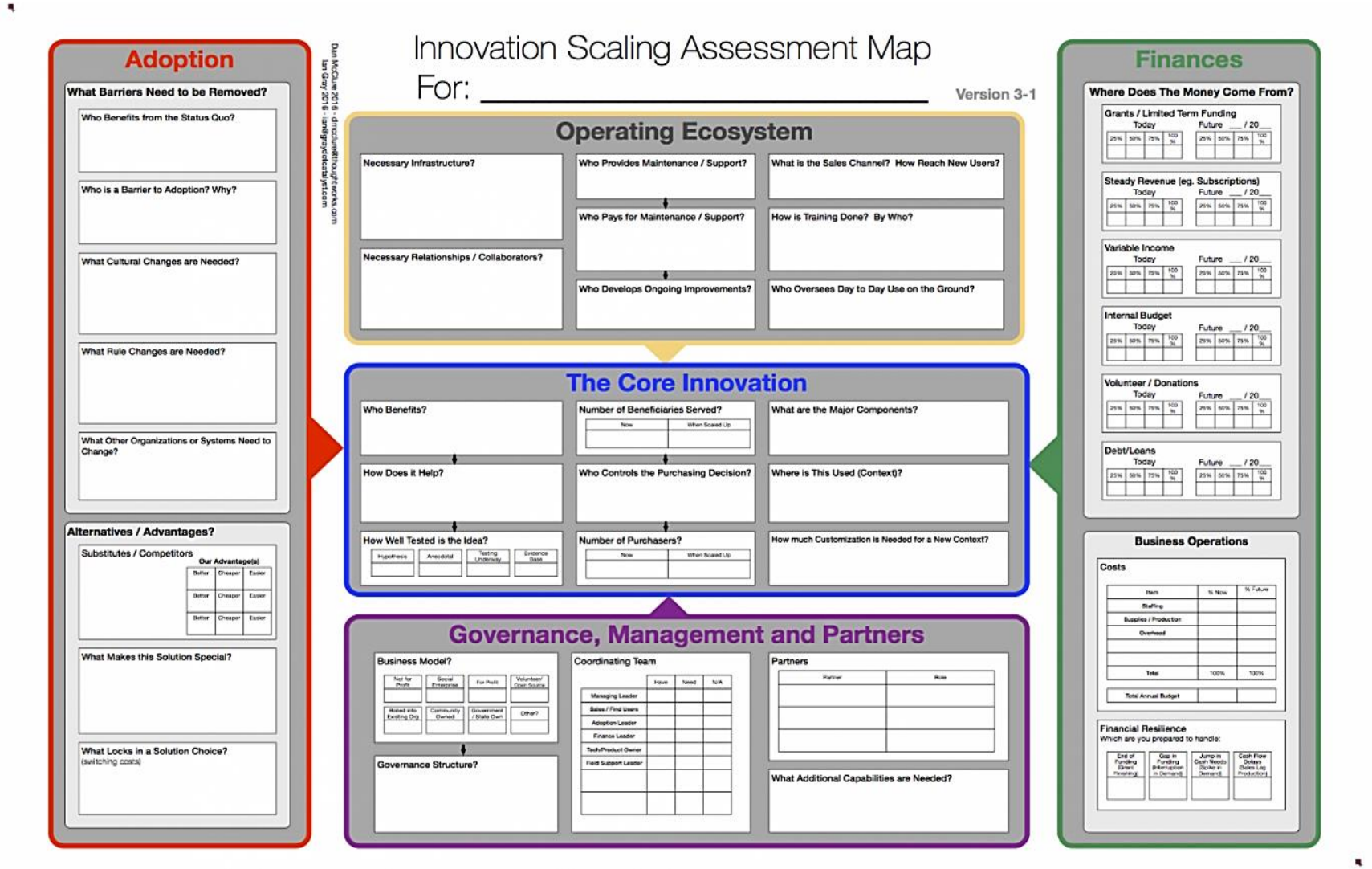


Figure 4: Innovation scaling assessment map (Sources: McClure and Gray 2016; Dror and Wu 2020).

Theory of Change (ToC) and Impact Pathways (IPs)

For RRR business innovations to go to scale and have impact, there is the need to understand how the activities of the interventions are expected to lead to the desired outcomes. Researchers, policy-makers, donors and beneficiaries can rely on two concepts to support and track changes from lower to larger scales: Impact pathways and their distinct theories of change (ToC).

> *"Impact pathways describe … the linkages between the sequences of steps in getting impact. A theory of change adds to an impact pathway by describing the causal assumptions behind the links in the pathways – what has to happen for the causal linkages to be realized."*
>
> Mayne and Johnson 2015

With respect to **innovation readiness**, a plausible ex-ante **ToC** becomes crucial between the last steps of the TRL scale, i.e. where the technology leaves the controlled research environment and is facing new actors for real life validation and uptake. In other words, where the scaling readiness has been established, the impact pathway (IP) starts, supported by a ToC for every step from the first users to the next (larger) group, with clear roles of intermediaries and partnerships to make this happen. Where the readiness is not established, it can be too early for the ToC (Douthwaite et al. 2020).

In arriving at the desired outcomes, there are nested IPs including subpathways, which are dealing with intermediaries and others focusing on the beneficiaries.

There can also be intermediaries' pathways among the multistakeholder groups resulting in a rather complex overall IP addressing research, capacity development and interactions with 'enablers' like policy-makers or donors whose actions influence the behavior of others (Mayne and Johnson 2015).

ToCs are indicated to set out how scaling up to the community and to the regional level is intended to work up to the improving outcomes for the beneficiaries— food security, poverty, etc.

Ultimately, nested ToCs will show how the different parts of the RRR intervention fit together and can provide a framework for a monitoring and evaluation plan that identifies what information is needed for which ToC and when.

> *A ToC for each step of a "scaling framework" would be very beneficial in articulating just how scaling is envisaged in the case at hand and in developing a scaling implementation strategy.*
>
> Mayne and Johnson 2015, modified

Such ToCs and IPs have to be continuously reassessed for possible changes in their assumptions and support options. It is recommended to record and assess in this context not only the anticipated but also unintended outcomes and impacts, as the downscaling example showed (Child et al. 2021).

Conclusions

- Most **innovation readiness** frameworks describe the childhood and early adolescence years of an innovation, which rely for actual scaling on plausible ToCs and IPs. Scaling readiness and ToCs/IPs are thus complementary concepts in principal.

- All frameworks for scaling RRR business innovations should be questioned, tested, refined and used thoughtfully, especially where the innovation moves from a controlled to an uncontrolled environment.

- Scaling Readiness is a relevant concept for scaling technology innovations such as Fortifer and waste-based solid fuel.

- The BRLa offers complementary strength with its emphasis on different external factors which steer the enabling environment of RRR business models.

- The SAM tool is a useful addition to the business model canvas by linking components, e.g. of a financial business plan with scaling.

- An ex-ante TOC is a crucial tool to articulate expected causal changes and related assumptions and requires continuous reviews and updates. There are various ways how Research for Development can support ToCs especially if the innovation package includes stakeholder dialogues, platforms, etc.

- Scaling RRR business innovations will spread through diverse routes such as building networks, franchising, licensing, joint ventures (PPP), mergers and acquisitions, and communities of practices which have to be captured. Given the complexity of options any scaling pathway should have an integrated ToC (Mayne and Johnson 2015).

- For adaptive scaling, the analysis and support of the external enabling environment becomes crucial. There are practical multidisciplinary tools available to analyze related scaling opportunities and barriers, such as those presented by Otoo et al. (2016), Minh et al. (2021) and Izzi et al. (2021).

- For impact tracking, it is recommended to record and evaluate not only the anticipated but also unintended outcomes and impacts.

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Appendix 1: Screened scaling innovation frameworks

	Name of scaling framework	Developers	Year	Purpose	Applications	Scaling position	Method
1	Scaling scan	PPP lab and the International Maize and Wheat Improvement Centre(CIMMYT)	2017 and updated 2018	Helps to understand dimensions of scaling and the role of nontechnical factors in a scaling mindset. It can be used to check if project proposals, implementation plans and evaluations are 'scale-proof'.	• Not sector specific, but mainly used in the agriculture and water sector • Application: Netherlands, Mexico, Kenya, India, Nepal, Uganda and Tanzania	Between conception and the detailed implementation stage	Facilitated workshop
2	Operational Framework for scaling up results (IFAD)	IFAD	2015	Systematically scaling IFAD's operations from conception to completion and in different contexts. Aims to guide and stimulate operational approaches and complement IFAD's operational policies.	• Ask the question what works and what is to be scaled up • Agricultural investment programs in general but relatively weak applicability across sectors	Start of the process to guide IFAD staff in thinking about scale-up options from the germination of a concept	Facilitator setting
3	Nine steps for developing a scaling up strategy	ExpandNet	2010	Facilitates systematic planning and outlines a concise, step by step process for developing a scaling up strategy.	• Health policies and programs • Innovations related to nutrition and the development sector in general • Application: Asia, Africa and Latin America	Very general; covers the whole scaling cycle	
4	Assessing scaling potential tool	World Resource Institute (WRI) with the support of GIZ	2016	Helps project planners to rapidly test for scalability of projects from the design phase to the postimplementation phase.	• Suitable for pilot projects • Various sectors involved in planning (environment, climate, agriculture, transportation, and sustainable development	Any stage of project implementation to test for scaling potential	Group or individual

5	Scalability assessment and planning toolkit	Save the Children International	2019	Effective assessment and planning with corrective actions to strengthen or enable scaling up of an idea or solution. Used for portfolio management and comparing different projects.	• Applicable for those working with children • Developed tool from ExpandNet, WHO, MSI and UNDP	At end of a pilot to assess scalability and plan for scaling up and during the design phase	Program managers and technical advisors
6	Scaling up – from vision to large-scale change	Cooley and Kohl 2006; https://msiworldwide.com/additional-resources/msi-scaling-framework	2006 2012 2016	Aims to support investors and donors to understand and assess the scalability of proposed interventions.	• General framework to support several interventions	No specific sector. Appropriate for development innovations or technologies in general Covers the whole scaling cycle	Group setting with discussion among innovation researchers, project staff, implementers and other stakeholders
7	Scaling assessment map	McClure and Gray 2015, 2016	2015	Supports the evaluation of planning for pilot innovation programs to reach the goal of replication and optimization in multiple contexts.	• Template similar to a business model canvas to continuously improve the scaling model • Suitable for commercial products with social missions and a more business-oriented environments	Humanitarian innovation Focuses more on perspectives of product design for a profit company or a social enterprise at the planning stage, but broadly applies to the social sector	Applied when the innovation enters the scaling up stage after the pilot programs are done. Requires a valid business case and continues to be developed into a higher-level strategy

8	Agricultural scalability assessment tool (ASAT)	E3 Analytics and Evaluation project	2018	Helps select an appropriate scaling pathway for an innovation through a qualitative appraisal of the scalability. Overall aim is to improve USAID's internal decision-making by identifying innovations with the greatest potential for both successful scaling, significantly improving food security and reducing malnutrition.	• Scaling up of drought-tolerant maize in Zambia, • Poultry breeds in Uganda, hermetic bag technology in Kenya, agricultural machinery in Bangladesh, Sahel rice varieties in Senegal	ASAT used during project from research and design to implementation as is designed to inform decisions. Used to integrate scaling up considerations assess progress, decide whether scaling up makes sense, etc.	Recommended for small group discussions
9	Scaling Readiness (based on Technology Readiness Level)	NASA, Mankins 1995, 2009; Sartas et al. 2020; CGIAR RTB CRP	2009; 2020	Developed to assess technology readiness; extended to other innovations.	• Global application • All sectors • CGIAR RTB CRP	Early stage of the intervention and also after testing and validation	Project managers, workshop formats or use of expert ranking i.e. Delphi approach
10	PATRI Framework	Rizwan Tayabali with support from Ashoka Globalizer and GIZ	2014	Developed to bring different scaling processes together in one document.	• Health care sector and business applications • Built with a business model option, but not detailed business canvas	Target mid-sized impact organizations with proven multidimensional solutions worth scaling	Participatory with series of questions
11	5 RRR framework	Dees et al. 2004	2004	Supports strategies to scale social impact.	• Global but mainly in the USA • Targets social innovation	Covers the entire innovation cycle	Participatory
12	SUN Framework (Scaling up Nutrition)	Collaborative efforts of international organizations and donors	2011	Framework for key considerations, principles, and priorities for action to address malnutrition.	• Malnutrition • Global application	Organization working on nutrition and planning to scale up	Participatory with multistakeholders

13	Four guiding principles for scaling impact	McClean and Gargani	2019	Provide different scaling frameworks based on scaling science.	• Central America, • Latin America	Designed for early stages to actual implementation	Facilitation
14	IDIA framework	IDIA working group, Thomas Feeny and Johannes Linn at Results for Development	2017	Collection of insights that may be helpful for funders.	• Global	Organization working in the global south on various innovations	Facilitation
15	A learning process approach	Korten	1980	Rural development, the background of participatory research practices.	• Global	Planning and learning	Facilitation and participatory
16	Paths framework for product introduction	PATH (Programme for Appropriate Technology in Health)		Developed to assess readiness of health technologies.	Health technologies	Planning	Facilitation and expert style format
17	Five configurations for scaling up social innovation	Westley et al.	2014	Developed for social and entrepreneurs.	• Nonprofit • Social • Entrepreneurship	Learning and Adapting	Experimentation
18	Making it big – strategies for scaling social innovations	Madeline Gabriel, supported by Nesta	2014	Focus on strategies for scaling social innovation.	• General – social entrepreneurship	Scaling routes are based on influence, delivery networks; strategic partnerships and organizational growth	Participatory and expert format style
19	A phased approach	Baker 2010	2010	Strategies of taking programs to scale.	• Phased in approach • Applicable to business • USA (Georgia)	Identifying, planning and implementation	Group facilitation, expert implementation style

20	Innovation platforms	ILRI and many others Totin et al. 2020		To use [multi-]stakeholder platforms or learning alliances [within or across scales] for knowledge sharing on common interest innovations.	• Novel technologies, practices and business models • Global south	Part of impact pathway for information dissemination, learning, replication	Stakeholder platforms, Crowd sourcing
21	The scalability framework	Weber et al.	2012	Developed to support social and entrepreneurs to scale innovations.	• Social entrepreneurship	Adapting	Facilitation and expert style format
22	Vuna-DFID framework	Four-step process for assessing scalability of innovations or interventions; Anandajayasekeram 2016	2016	Documents lessons on why pilot projects do not scale up successfully.	• Zimbabwe and • Zambia	Covers the entire innovation cycle	Participatory, empowering and mobilization
23	Balanced Readiness Level Assessment	Vik et al.	2021	Developed to add different dimensions to the technology readiness level framework.	• Agriculture • All other sectors • Various locations	Identifying, replication and implementation	Facilitation, expert implementation format
24	Adaptive scaling framework	IWMI	2021	Developed to support farmer-led irrigation development programs within distinct enabling environments.	• Agriculture, water sectors • West Africa	Covers various functions in the scaling ecosystem	Facilitation and workshop format

Appendix 2: Balanced Readiness Level Assessment Framework (after Vik et al. 2021)

Questions	TRL Development	MRL Commodification	RRL Legalization	ARL Legitimization	ORL Domestication
1	Is this technology fully developed and ready to use?	Is the product available in a market through a defined business model?	Is use and production of the technology regulatory unproblematic?	Is use and production of the technology socially accepted in general?	Can the technology be used seamlessly together with existing technologies?
2	Has the technology been tested and validated in a broad scale?	Is product demand stable or growing?	Does use and production of the technology fulfill general requirements?	Is use of the technology seen as questionable within marginal interest groups?	Is the technology adapted to work processes and/or other technologies?
3	Has the technology been tested and validated in a natural environment?	Has there been demand for the product in the market?	Are the necessary approvals/permissions close to being given?	Is the technology seen as questionable in parts of the sector	Are only minor organizational changes needed?
4	Has a prototype been tested and validated in a relevant environment?	Has the product been sold in small amounts?	Are needed approvals/permissions likely?	Is the technology seen as questionable by a few actors in the sector?	Are major organizational changes needed for the technology to be used?
5	Have core components been tested together and validated in a laboratory/simulated environment?	Is there a described business model?	Will use of the technology require easily accessible permission?	Is the technology seen as questionable among key actors in the sector?	Is there a plan for integration of the technology with existing work processes?
6	Have the core technological elements been tested and validated one by one?	Is the market demand and the idea confirmed by customers and market actors?	Will use of the technology require demanding permissions/approvals?	Is the technology seen as questionable among groups of the population?	Has potential integration and domestication of the technology been described?
7	Has a concept been clearly demonstrated and described?	Has a market demand and a product been explicated?	Will use of the technology require regulatory changes?	Is the technology seen as very questionable among groups of the population	Has an idea regarding integration/domestication been formulated?
8	Has the idea been explicitly described	Has an idea regarding a need and technological solution been formulated?	Will use of the technology demand legal changes?	Is the technology controversial among large part of the population?	Is integration with existing work processes unclear or problematic?
9	Has a specific technological idea been formulated?	Does an idea regarding a market need exist?	Are the legal and regulatory aspects of the technology unpredictable/unknown?	Will the technology be seen as illegitimate or socially unacceptable?	Will the technology represent a fundamental break with existing work processes?

TRL: technology readiness level; MRL: market readiness level; RRL: regulatory readiness level; ARL: acceptance readiness level; ORL: organizational/institutional readiness

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