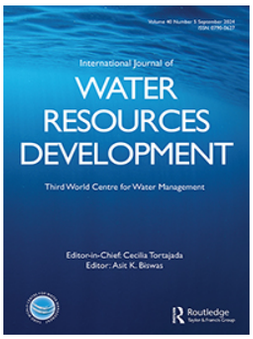

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Agricultural innovation platforms for scaling innovations – insights from the Transforming Irrigation in Southern Africa project

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ABSTRACT

A major challenge in agricultural research for development is understanding how agricultural innovation platforms (AIPs) scale innovations to maximize environmental and socioeconomic benefits. Multilevel perspective and anchoring frameworks were used to assess the effectiveness of AIPs in anchoring innovations to go to scale under the Transforming Irrigation in Southern Africa project. Resultant scaling approaches, and whether and how scaling impacts were sustained are assessed at the sociotechnical regime. AIP collective capabilities ensured anchoring strategies and scaling approaches utilized by AIPs led to the embedding of innovations within the agricultural sociotechnical system. This resulted in changes in policy, behaviour and practices.

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Agricultural innovation platforms; development; irrigated agriculture; scaling; sustainability

Introduction

Scaling is a concept that has rapidly gained momentum over the last decade within Agricultural Research for Development (AR4D) spaces, more so in the Global South, due to the increased need for widespread adoption and institutionalization of technologies and their impacts (Bradach & Grindle, 2014; Gebreyes et al., 2021; Shilomboleni & De Plaen, 2019). Despite scaling becoming such a popular concept and attracting the interest of many agencies, the science and practice of scaling still remain at early development stages (Gebreyes et al., 2021). Scaling agricultural innovations most often fails due to the approach of identifying what works and doing more of the same at a wider geographical scale (Bradach & Grindle, 2014; Chester, 2005; Do, 2019; Wigboldus & Leeuwis, 2013; Wigboldus et al., 2016; Woltering et al., 2019), which has been defined by Shilomboleni and De Plaen (2019) as a linear approach to scaling. Such a linear approach to scaling may cause unintended and unexpected negative impacts, such as environmental degradation on receiving environments and exclusion of some end-users (Tarhan, 2021; Wigboldus & Leeuwis, 2013; Wigboldus et al., 2016).

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Despite the poor portrayal of scaling in most literature, it is not an elusive process and can be achieved through better understanding of scaling theory and practice. Contemporary research aims to identify more effective methods for scaling. For instance, Totin et al. (2020) argue that there is growing evidence that agricultural innovation platforms (AIPs) provide excellent enabling environments for the scaling of innovations such as business models, new technologies and agricultural practices. Innovation is defined as 'the process of application of new or existing knowledge in new ways and contexts to do something better' (Makini et al., 2013, p. 45). Although AIPs are most often portrayed in a positive light in relation to innovation, empirical studies that investigate how AIPs operate to scale agricultural innovations have been limited (Hermans et al., 2017). We seek to fill this gap by exploring scaling theory and empirical evidence from the Transforming Irrigation in Southern Africa (TISA) project implemented in two phases (TISA1 and TISA2) from 2013 to 2023 in Mozambique, Tanzania and Zimbabwe. The study areas for this research are located in sub-Saharan Africa, where a little over 70% of the poor reside in rural areas and are highly dependent on rainfed production of staple crops as a source of food and livelihood (Arment, 2020; Burney & Naylor, 2012; Kydd et al., 2004). However, yields from staple production in this region are generally low as they are subject to weather fluctuations and water shortages. Production is limited to the rainy season, which typically extends for periods of between 3 and 6 months (Burney & Naylor, 2012). Irrigation agriculture has been widely promoted for supplying supplementary water in water scarce regions including sub-Saharan Africa (You et al., 2011). The TISA project has been implemented in countries where irrigation is a priority area for the agricultural sector. All three implementation countries are committed to the Comprehensive Africa Agricultural Development Programme (CAADP), a policy framework for transforming African agriculture initiated by the African Union (AU; Pittock & Ramshaw, 2016). The countries also have nation-specific policy and programmes that have objectives for irrigation development.

The objective of this paper is to assess the effectiveness of AIPs in anchoring innovation to go to scale, effect and sustain transformations at the sociotechnical regime level (hereafter referred to as the regime). The paper utilizes the multilevel perspective (MLP) and anchoring frameworks to improve understanding of how AIPs can be conduits for moving agricultural innovations from the pilot/proof-of-concept phase to achieving impact at scale. Previous studies have utilized the combination of the two frameworks to assess the potential for scaling in projects after the pilot/proof-of-concept phase (Elzen et al., 2012; Polita & Madureira, 2021; Seifu et al., 2020). This paper goes further to determine the scaling approaches that have been utilized to scale agricultural innovations over a 10-year period and how scaling impacts were sustained within the regime. The paper is structured as follows: the next section provides the theoretical framing, followed by a section that presents the methods utilized for this research; the subsequent section presents the results of the study, the penultimate section is the discussion section and the last section contains conclusions and recommendations.

Theoretical framing

Scaling dimensions, strategies and mechanisms

Dimensions to scaling

Moore et al. (2015) utilize the conceptual language of scaling out, scaling up and scaling deep to differentiate scaling dimensions (as depicted in Figure 1). Scaling out or horizontal scaling refers to quantity and may be seen as doing more of the same, expansion, extension, adoption or multiplication, depending on the object of scale (Hartmann & Linn, 2007; Moore et al., 2015; Omann et al., 2020; Wigboldus & Leeuwis, 2013). Dominant scaling up definitions have a strong emphasis on governance. The definition of Van den Bosch and Rotmans (2008) is applied here, which states that scaling up involves influencing and embedding new ways of thinking, doing and organizing. Scaling up is about transforming the systems that have led to the manifestation of the problem in the first instance so that they become part of the solution (Woltering et al., 2019). Scaling deep is concerned with changes in cultural beliefs and values; it not only involves changes in mindsets and worldviews, but stretches to include transformation of hearts and relationships (Moore et al., 2015).

Although the scaling dimensions are often discussed separately, they are interrelated – no single dimension can occur in isolation (Hartmann & Linn, 2007). One form of scaling dimension will trigger other forms; for example, as projects or innovations scale to a wider geographical spread to reach many, they often need to scale culturally, politically and organizationally (Wigboldus & Leeuwis, 2013). Scaling at lower levels may influence or be influenced by the political and power dynamics at higher levels (Sartas et al., 2020). Moreover, scaling may not have effects within the same sector, but may impact other sectors; for example, scaling in the agricultural domain may have an impact on the health domain (Sartas et al., 2020). The interplay of scaling dimensions discussed above requires

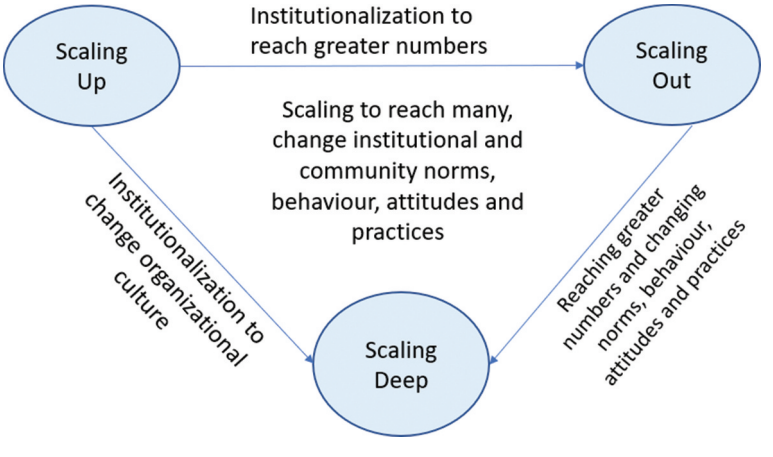

Figure 1. The three scaling dimensions (scaling out, scaling up and scaling deep). Source: Adapted from Moore et al. (2015).

that those leading the processes of scaling employ strategies to adapt to different contexts, institutions and cultures. These strategies are discussed below.

Strategies for scaling out, up and deep

Three scaling strategies are identified by Gebreyes et al. (2021): scale jumping, scale bending and scaling down. Although literature on these strategies is still limited, this section gives a brief introduction to them. Scale jumping is where actors involved in scaling extend the political influence established at one scale to another scale. It is an intentional effort, which is facilitated when there is a realization that some of the aims of scaling will not be achieved at lower levels and need to be escalated to higher levels.

Scale bending is concerned with actions of individuals and groups that challenge the status quo. They go against the assumption that there are certain decisions that need to be made at specific levels (Gebreyes et al., 2021). According to Gebreyes et al. (2021), scale bending in agricultural innovation can involve new ways of overcoming or going against policy, market and regulation obstacles faced by a group of people. The group will adopt mechanisms such as advocacy, lobbying and championing.

Scaling down involves the devolution of power to local levels and this is normally done when there is a need to embed high-level decisions into local cultural and place-based interests (Gebreyes et al., 2021). Scaling down can also mean that those involved in scaling efforts have realized that an agricultural innovation does not require expansion due to the risks it may cause to the environment or end-users. Wigboldus et al. (2016) and Woltering et al. (2019) cite this as responsible scaling. Scaling mechanisms, such as farmer to farmer learning, experiential learning, extension service-led learning and research-based learning, provide information and evidence from real-life contexts required to determine how agricultural innovation can be scaled to areas with similar operational environments or adapted to suit those areas with differing environments (Muilerman et al., 2018).

The role of AIPs in facilitating agricultural innovation and scaling

AIPs are referred to as living labs in contemporary literature because they facilitate interaction among a group of key stakeholders around a shared interest, where stakeholders play various but complementary roles in experimentation, innovation and co-creation (Bouwma et al., 2022; Makini et al., 2013; Schut et al., 2019). The forums can be formed at three different levels: operational/local, intermediary/provincial and national (Makini et al., 2013). Despite the level at which the AIPs are formed, they are generally expected to create an enabling environment for institutional and technological innovation and to facilitate effective scaling of agricultural innovations (Sartas, 2018). Despite the high expectations placed on AIPs in facilitating innovation and scaling, their performance has varied, as each AIP is tailor-made for a specific agricultural challenge (Sartas, 2018).

AIPs have been promoted as forums that can contribute towards achieving impact at scale; however, this assertion is not yet universally accepted (Faysse, 2006). Proponents of AIPs, including Bjornlund et al. (2020) and Van Rooyen et al. (2017), argue that AIPs are particularly suited to come up with innovative solutions for constraints faced by complex systems including irrigation schemes. Critical aspects that ensure AIPs fulfil their mandate

of innovating and scaling include collective abilities (Wigboldus et al., 2023), having the right facilitator (Swaans et al., 2013) and continuous learning and negotiation (Bouwma et al., 2022; Körner et al., 2021).

The multilevel perspective and anchoring frameworks

The multilevel perspective

The MLP is an analysis framework utilized to understand processes of transition and system innovation, and the capacity to engage with scaling from a systems perspective (Elzen et al., 2012; Geels, 2005; Polita & Madureira, 2021; Seifu et al., 2020; Wigboldus et al., 2023). The MLP proposes three sociotechnical systems, the niche (micro-level), regime (meso-level) and landscape (macro-level; Elzen et al., 2012; Geels, 2002; Wigboldus et al., 2023). This perspective presents niches as spaces where various actors apply their collective capabilities to facilitate radical innovation, normally under protected environments such as those of project funding, knowledge and skills (Elzen et al., 2012; Shilomboleni & De Plaen, 2019; Wigboldus et al., 2016). This study identifies AIPs as niches. The regime level is defined as the sociotechnical systems whose practices, structures and rules have reached relative stability and are part of the status quo within a community, society and institutions (Geels, 2005; Seifu et al., 2020; Wigboldus et al., 2023). Innovations facilitated within the niche can penetrate the regime to cause transformations in the manner in which the regime functions (Elzen et al., 2012; Geels, 2005; Seifu et al., 2020). For this study the regime is identified as the agricultural system. The landscape level represents context variables and the wider context in which the introduction of innovations and system changes occur, including political and environmental conditions (Seifu et al., 2020; Wigboldus et al., 2023). These conditions are constantly changing and exerting pressure on the regime to adapt and evolve to be more effective and sustainable (Seifu et al., 2020; Wigboldus et al., 2023). This study considers variables such as climate change, increased population, market factors and governments' increased focus on irrigation agriculture as exerting pressure on the agricultural system to become more productive, profitable and sustainable.

It has been argued that the MLP framework is only capable of exploring capacity to engage with scaling from a systems perspective, but does not explore the perspective of collaborative capabilities for taking innovations to scale (Wigboldus & Brouwers, 2016; Wigboldus et al., 2023). To understand how multistakeholder platforms such as AIPs function to scale innovations, this study combines the MLP and the anchoring frameworks.

The anchoring framework

Anchoring is presented in literature as a framework that explores the process of linking between the niche and regime level. It is concerned with how the activities of actors within the niche penetrate the regime to a point where niche practices are translated into regime components (Seifu et al., 2020; Smith et al., 2010). In order to effectively scale, a mix of network, methodological and innovation, and institutional anchoring is required (Elzen et al., 2012; Seifu et al., 2020). Methodological and innovation anchoring are those efforts around the proposal and selection of a new product or practices, involving introducing these new ways to regime actors for learning, experimentation, implementation and adoption (Elzen et al., 2012; Polita & Madureira, 2021). Network anchoring

concerns the efforts made to connect relevant and strategic actors at user, implementation and decision-making levels (Polita & Madureira, 2021). Institutional anchoring requires the adoption of mechanisms such as lobbying and negotiation at the level of relevant authorities within the regime, to stimulate conducive policies, incentives and funding (Seifu et al., 2020). Consistent and widespread use of innovations also promotes institutional anchoring because this helps create informal rules, routines and mindset changes that are increasingly known and applied by growing numbers of actors within the regime (Polita & Madureira, 2021).

Methods

Study areas

TISA project interventions have targeted ailing irrigation schemes in Mozambique, Tanzania and Zimbabwe. The TISA project has been implemented in two phases, with TISA1 being implemented between 2013 and 2017 and TISA2 from 2017 to 2023. During this period the project has targeted smallholder irrigation schemes using a two-pronged approach of AIPs and soil moisture and nutrient monitoring tools (Pittock et al., 2020). TISA1 targeted two irrigation schemes in each country: 25 de Setembro and Khanimambo irrigation schemes in Mozambique, Kiwere and Magozi irrigation schemes in Tanzania and Silalatshani (Landela block) and Mkoba irrigation schemes in Zimbabwe. Under TISA2 a total of 41 irrigation schemes were engaged (see Figure 2).

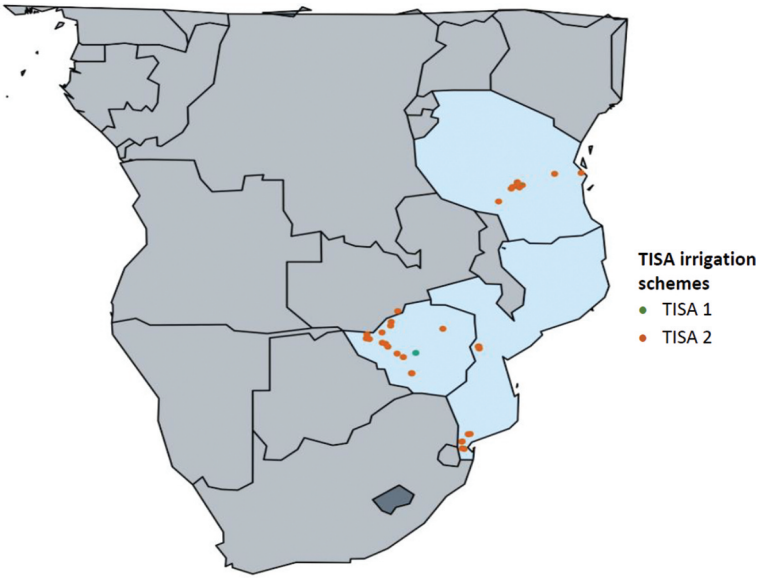

Figure 2. Map of TISA irrigation schemes.

Research methods

A case-study approach was utilized for this research as it allows for the in-depth exploration of empirical evidence within its real-life context (Yin, 1994). The multiple case-study approach was applied focusing on the three TISA project implementation countries and targeted irrigation schemes. The case-study approach was also selected because it allows for the exploration of data from mixed sources. Case-study data utilized for this study include TISA project proposals, project reports, AIP meeting reports and semistructured interviews with AIP members and other relevant stakeholders in Zimbabwe. Secondary data utilized for this study include TISA project proposals and reports, AIP meeting reports, and data collected as part of TISA and reported in Mdemu et al. (forthcoming) for Tanzania; Moyo et al. (forthcoming) for Zimbabwe and Tafula et al. (forthcoming) for Mozambique. The data were collected by country research teams through household surveys with TISA and non-TISA (those not targeted by TISA) irrigation schemes, farmer field books, focus group discussions, workshops and field observations. The data collected by research teams were utilized to determine how scaling impacts were sustained during the two phases of the project. Primary data included semistructured interviews with 24 AIP members and other relevant stakeholders in Zimbabwe, and direct communication with 5 TISA staff members. A combination of the MLP and anchoring frameworks as discussed in the theoretical framing section was utilized to analyse the data using the three forms of anchoring (network, methodological and innovation, and institutional) to determine the strategies utilized by AIPs under the TISA project to effectively anchor agricultural innovations within the regime to facilitate scaling of innovations to the appropriate governance level. The collective capabilities of Wigboldus et al. (2023) were utilized to determine the abilities required by AIPs to anchor and scale agricultural innovations.

The ethical aspects of this study were approved by the Australian National University Human Research Ethics Committee (Protocol 2022/519). Project information sheets in the local language were provided to all research participants and the lead author gave a verbal explanation of the research and expectations. All participants gave either written or verbal consent.

Results

Anchoring strategies

This section explores the anchoring strategies utilized by AIPs under the TISA project for innovations to go to scale (see Table 1), which are discussed further in the subsections that follow. The three anchoring types of methodological and innovation, network and institutional are utilized to assess the strategies in column two of the table based on an analysis of TISA project proposals, reports, papers, AIP meeting reports, and records and interviews with AIP members and other stakeholders in Zimbabwe. The requisite collective capabilities (adapted from Wigboldus et al., 2023) required for AIPs to implement the anchoring strategies are explored in column three.

Table 1. Overview of anchoring strategies and AIP collective capabilities.

Type of anchoring	Strategies utilized by AIPs	Pre-requisite AIP collective capabilities (adapted from Wigboldus et al., 2023)
Methodological and innovation	(1) Co-creation and inclusive innovation in AIP spaces (2) Training local-level actors to facilitate AIPs (3) Utilization of district-level AIPs as platforms for irrigators to share innovation experiences (4) Ability of AIPs to evolve and transform to structures that solve systemic challenges (5) Engagement of irrigators in the AIPs in leading decision-making processes around innovation (6) Engagement of 'powerful' actors with the ability to effect transformation at high levels (7) Strengthening the capacity of AIP members to innovate and scale within and outside the forums	Capability to: (1) resource and act (2) adapt and navigate (3) balance diversity and coherence among actors (4) make scaling contribute towards sustainable development
Network	(1) Amalgamated social networks created within AIPs (2) Leveraging member networks outside the AIP (3) Leveraging existing social capital, e.g. lead farmers (4) Leveraging local agricultural support structures, e.g. agricultural extension (5) Leveraging development partners, e.g. NGOs (6) Circulation of innovation information at scheme-level meetings	Capability to: (1) relate and partner
Institutional	(1) A mix of top-down and bottom-up approaches utilized to support the scaling process at different levels (2) Engagement of institutions that are not normally part of participatory value chain spaces, e.g. the private sector	Capability to: (1) Link the innovations in institutions

Source: Authors.

Methodological and innovation anchoring strategies

For methodological anchoring to occur (to anchor the AIP method/process), the TISA project provided financial support for the establishment of AIPs and identified stakeholders who participated in the initial meetings. Stakeholders included irrigators, community-level extension services, the private sector, the financial sector and non-governmental organizations (NGOs; Bjornlund et al., 2020; Chilundo et al., 2020; Mdemu et al., 2020; van Rooyen et al., 2017). The collective ability of balancing diversity and coherence among actors was witnessed through bringing together stakeholders that are perceived as 'more powerful' and those that are perceived 'less powerful' who have historically not been able to come together in decision-making spaces. The TISA project team took the lead in introducing the concept of the AIPs to the stakeholders as a new concept. However, in subsequent meetings, local stakeholders such as agricultural extension staff, chaired the meetings.

The AIP process developed the capacities of participants to identify problems and opportunities, assess and prioritize those for action, and implement chosen innovations (see the online supplemental data for participants' accounts of the process). The process included (i) a visioning exercise to assess the current situation of their schemes and where they want to be in five years; (ii) identification of barriers to achieving the vision; and (iii) identifying solutions and stakeholders to implement them. At this stage the AIPs recruited new members if additional skills were needed to implement the solutions. Examples of system challenges identified through the Silalatshani scheme level AIP in Zimbabwe included high water tariffs, unsustainable income and government-initiated cropping

calendars. These challenges were resolved through the AIP process (van Rooyen et al., 2020). The resultant innovations are discussed in the next section.

Analysis of TISA project reports and AIP meeting reports found that through their collective ability to resource and act, AIP participants under the TISA project initiated a total of 22 hardware, software and orgware innovations within the three countries (see Table 2). The innovations included core innovations, which are innovations that were intentionally set out to scale, as well as complementary innovations (see the Discussion for an example of an innovation package). Based on lessons learnt in the pilot phase of the project (TISA1), especially around the high cost of establishing new AIPs, the project made a decision to not only focus on scaling the AIPs and the soil moisture and nutrient monitoring tool interventions, but to scale them in conjunction with AIP core innovations such as linkages to input and output markets. However, for the project interventions and core innovations to scale effectively there was a need to also scale complementary innovations such as gross margins training and the introduction of new crop varieties. Four of the 22 innovations facilitated by AIPs were categorized as hardware innovations, 8 as software innovations and 10 as orgware innovations.

Table 2. Agricultural innovations applied in the Transforming Irrigation in Southern Africa project (2013–2023).

Hardware – new technological devices and practices (Leeuwis & Aarts, 2011)	Software – new knowledge and modes of thinking (Leeuwis & Aarts, 2011)	Orgware – new social institutions and forms of organization (Leeuwis & Aarts, 2011)
Inclusive installation (farmers involved in the installation) of soil moisture and nutrient monitoring tools (Chameleon and Fullstop) (*core innovation*)	Gross margins training (*complementary innovation*)	Participatory mapping (*complementary innovation*)
Soil fertility analysis (*complementary innovation*)	Farmer exchange visits/look and learn visits (*complementary innovation*)	Linkages to input and output markets (*core innovation*)
Showcasing new crop varieties and agronomic practices through demonstration plots (*complementary innovation*)	Training in the use of soil moisture and nutrient monitoring tools (*complementary innovation*)	Collective bargaining (inputs and outputs) (*complementary innovation*)
Diversification of crops, introduction of high-value crops (*complementary innovation*)	Farmer-led on-farm data collection (using field books) (*complementary innovation*)	Water pricing negotiations (*complementary innovation*)
	Workshops on improved agronomic practices (*complementary innovation*)	Crop calendar changes (*complementary innovation*)
	On-the-spot training on specific agronomic issues (*complementary innovation*)	Water scheduling changes (*complementary innovation*)
	Cloud-based soil monitoring tools (Virtual Irrigation Academy) (*core innovation*)	Farmer collective action (e.g. rehabilitation of irrigation infrastructure) (*complementary innovation*)
	Changes to irrigation scheme constitutions (*complementary innovation*)	Contract farming (*complementary innovation*)
		Linkages to financial institutions (micro-financing) (*core innovation*)
		Changes in irrigation management committees (*complementary innovation*)

Source: Authors.

The AIPs have not been static niche structures – they evolved and transitioned from the role of scaling innovations to that of innovating to resolve systemic barriers, therefore strengthening the adaptive capacity of its members within and outside the AIPs. An example of this adaptive capacity is that of Tshongokwe Irrigation Scheme finding itself with excess vegetables during COVID-19 lockdown with no physical access to the AIP to resolve this challenge. The irrigators barter traded the vegetables for grain at the community level and engaged an output buyer from Bulawayo (the nearest big city) to purchase and collect the grain post lockdown.

A further study of project reports demonstrated that as part of long-term methodological anchoring, local-level stakeholders were trained to effectively facilitate AIPs to ensure their sustainability should there be continued need for the platforms in the future. A total of 276 government officers were trained through the TISA project. TISA2 integrated AIPs into already existing district-level structures, which brought together different irrigation schemes facing similar productivity barriers. The study found that AIPs at this level still delivered the same benefits as those at the irrigation scheme level, but in a more cost-effective manner as they eliminated the need for multiple scheme-level meetings. The district level AIPs were also utilized as spaces where TISA1 irrigators shared innovation experiences (see quote below) with new irrigation schemes under TISA2. This provided evidence of their effectiveness, thereby promoting the scaling out of innovations to the new irrigation schemes.

> The third meeting was more of a lesson, with us taking the lead in teaching others. The agenda was us; as lead farmers, teaching others what the tools were and how they work and whether they were of any help. We were teaching other farmers that these tools are very beneficial for those who take heed of our advice on how they (the tools) are used. (Irrigator 5)

Network anchoring strategies

Based on AIP records for each of the three countries, AIP membership ranged from 22 to 62 stakeholders with varying skills and capabilities depending on the level and the objective of the AIP. This is a demonstration of the AIP's capability to relate and partner and can also be perceived as the creation of new social networks to facilitate innovation, learning and scaling. These networks went beyond those of individual members and their institutions. Amalgamated social networks through the connections that the individuals and their institutions brought to the table were formed. These networks were a key facilitator of scaling innovations within and outside the AIPs, thereby extending the geographical and institutional reach of the innovations. Irrigators brought the most crucial social network, which were the communities that they represented as end-users of the innovations. Interviews with AIP members in Zimbabwe established that irrigator representatives and extension officers held meetings with other irrigators at their respective irrigation schemes to provide feedback around the proceedings and resolutions from AIP meetings (see the online supplemental data for quotes). An irrigation scheme member from Silalatshani Irrigation Scheme had the following to say:

> When we came back, we first sat down as a committee and it was resolved that we should call farmers in our sections and present to them the outcomes of the meeting. We duly did that and highlighted to the farmers all the key things that were discussed and the need to make sure Silalatshani thrives like other irrigation schemes so that we can get to the stage of

> contributing grain to the Grain Marketing Board and in that way feed other people in other places. (Irrigator 14)

These structures already existing at community level provided irrigators with information and evidence that determined their decision to adopt the innovations and subsequently influenced the scale-out process. The project also leveraged available social capital at irrigation scheme level by strengthening the capacity of lead farmers to innovate and share information around irrigation, agronomic practices and markets with their peers. This peer-to-peer learning proved a crucial element in scaling innovations within TISA and non-TISA irrigation schemes (Pittock et al., 2017). In Zimbabwe, farmers from Landela Block trained farmers from the first out-scaling scheme to instal and use the tools, which resulted in immediate trust in the tools and a much higher adoption of changes in irrigation management practices than during TISA1 (see the section on sustaining impacts of scaling innovations at the regime level).

AIPs also leveraged existing agricultural support structures at the local level, including extension officers, whose role was strengthened through software innovations such as gross margins training. The confidence of extension staff in providing agricultural advice and support was further boosted in TISA2 when the project researchers scaled down their engagement, thereby elevating local institutions mandated with the roles of irrigation scheme support. Local-level government staff also played a role in effectively anchoring and scaling up innovations from AIPs because of their existing reporting channels to the provincial and national levels. This was collaborated by an agricultural extension stakeholder who stated:

> We would also inform our principals as well through those meetings [that we talked about] so that they would know about the AIP decisions and what needs to be done at the irrigation schemes. (Government stakeholder 3)

NGOs played a major role in the provision of technical and financial backstopping to non-TISA irrigation schemes, and this promoted the geographical spread of the innovations. They also played a role in facilitating linkages with the private sector. An example of this in Zimbabwe is that of a local NGO that was a member of the Silalatshani scheme-level AIP coordinating discussions between irrigators and input and output markets for improved access to agricultural inputs and outputs.

Institutional anchoring strategies

Top-down and bottom-up approaches were utilized for institutional anchoring of innovations in the regime in the three countries. The bottom-up approach was utilized to allow for changes to be made within institutions and for policy reform to occur for more effective adoption of innovations at lower levels. An example of the bottom-up approach is that of Tanzania, where AIP members lobbied the Ministry of Agriculture and the Iringa District Council to construct a storage warehouse, install a rice mill and improve irrigation infrastructure. The top-down approach was also used when decisions around the innovations were made at the provincial and the national level. A good example is that of Tanzania, where inclusion of soil moisture and nutrient monitoring tools on the tax-exempt list by national-level entities made access easier and cheaper for local actors.

The bottom-up approach to the national level has had varying results in the three countries under TISA due to differing political and governance contexts. In Tanzania, conditions were more amenable to achieving scaling objectives at the lower level compared to the other two countries. National-level engagement in Mozambique yielded positive results; for example, key regulatory changes have been made by the government for irrigation associations based on lessons from the TISA project. In Zimbabwe, the bottom-up approach has mainly been witnessed through the soil moisture and nutrient monitoring tools being adopted by the Department of Irrigation. According to a Department of Irrigation Stakeholder in Zimbabwe, soil moisture and nutrient monitoring tools received from the Virtual Irrigation Academy (VIA) project were scaled down across the country at different irrigation schemes:

> We have installed the tools across all eight provinces, in 33 schemes with about 270 sensors installed across those schemes. (Government stakeholder 1)

In Tanzania, the bottom-up method was mainly applied at the district level, where there have been significant changes initiated, including participatory mapping which was conducted at three irrigation schemes to determine plot boundaries and sizes: the irrigators utilized hardcopy maps to ascertain plot sizes and calculate operation and maintenance costs (Mdemu et al., 2023). This aligns with the argument that not all innovations need to be scaled to the highest levels. If conditions are conducive at lower governance levels then innovations can still be successfully adopted and effectively spread.

Institutional anchoring also occurred through the AIP's engagement with institutions that do not normally participate in value chains, such as financial institutions and the private sector (van Rooyen et al., 2020). These institutions contributed significantly to creating spaces where innovations could be effectively applied. An example of this is in Tanzania, where the government channelled loans through financial institutions which became more accessible to irrigators at the local level (Mdemu et al., 2020). AIPs under TISA addressed market-related bottlenecks through engagements with the private sector to create new market linkages and improve access to input and output markets. Further, farmers learnt directly from buyers on issues around input and output grading, pricing standards and market-oriented production (Parry et al., 2020). This improved agricultural profitability catalysed significant policy changes at higher levels, such as changes in government-imposed cropping calendars in Zimbabwe.

The scaling process

The TISA project supported the scaling process through the integration of scaling into the project theory of change for both phases of the project. The research teams engaged in the concept of responsible scaling when making decisions around scaling the AIP intervention or the innovations initiated by AIPs. AIPs under the TISA project were established at scheme and district level (as highlighted in the Zimbabwean example in Figure 3) within the targeted sites. In TISA1, six AIPs were established at the irrigation scheme level. In Mozambique the AIPs were formed at 25 de Setembro and Khanimambo, in Tanzania at Kiwere and Magozi irrigation schemes and in Zimbabwe at Silalatshani and Mkoba

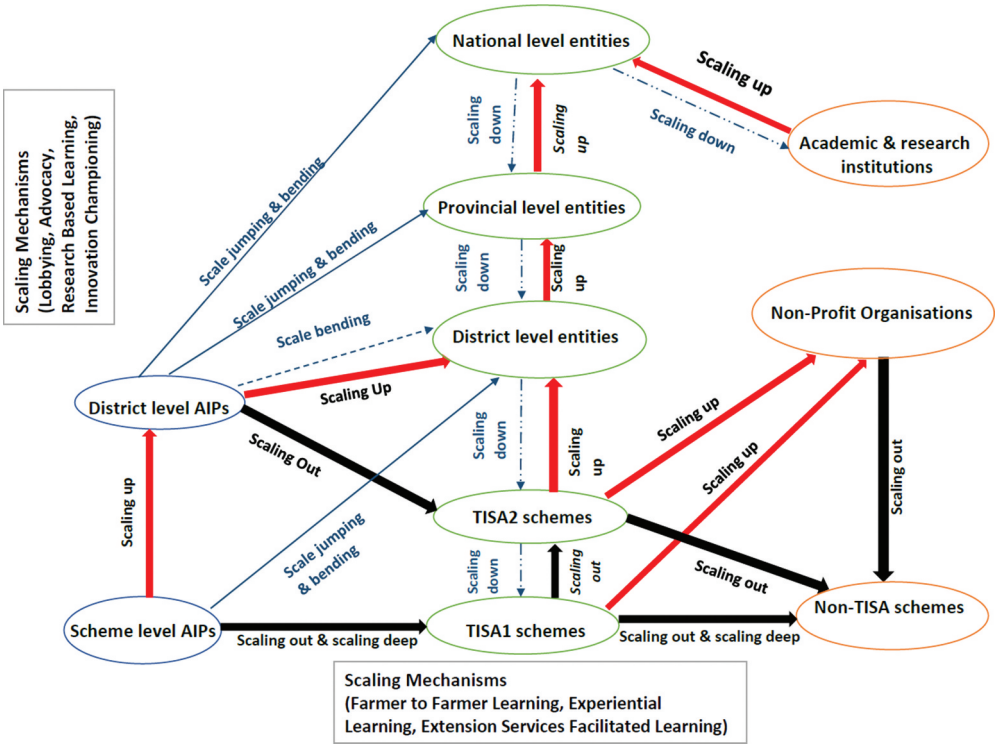

Figure 3. Example of the scaling of agricultural innovation process in Zimbabwe. Source: Authors.

irrigation schemes. Already established AIPs were utilized as conduits for scaling innovations to 12 new TISA irrigation schemes, and non-TISA irrigation schemes in TISA2 without establishing new AIPs. A total of 10 district-level AIPs were formed, which included the scale-up of the six irrigation scheme-level AIPs initiated during TISA1.

Agricultural innovations initiated by AIPs at irrigation scheme level (see Table 3 for examples of innovations and related scaling dimensions) were initially scaled out to six TISA1 supported irrigation schemes; those initiated by AIPs at district level were scaled out to 35 TISA2 irrigation schemes. The agricultural innovations have been scaled out to a total of 41 TISA supported irrigation schemes. Further scaling out occurred to non-TISA irrigation schemes through extension officers, businesses and NGOs. In Zimbabwe, the AGRITEX department in Insiza district distributed a maximum of two soil moisture and nutrient monitoring tools to irrigation schemes not supported financially and technically by TISA to encourage evidence-based learning (Government stakeholder 11). At the irrigation scheme and community level, scaling deep was driven by such mechanisms as the use of demonstration plots for experiential learning, the use of lead farmers to champion the innovations and exchange visits to stimulate learning outside the irrigator's usual context. At Silalatshani Irrigation Scheme in Zimbabwe, demonstration plots were scaled out from the Landela Block in TISA1 to four other blocks within the scheme under TISA2 to allow for experiential learning to occur at closer proximity to all irrigators. The

Table 3. Examples of TISA's agricultural innovations and related scaling dimensions.

	Scaling dimensions		
Agricultural innovations	Scaling out	Scaling up	Scaling deep
Hardware			
Soil moisture and nutrient monitoring tools installation	✓	✓	
Showcasing new crop varieties and agronomic practices using demonstration plots	✓	✓	
Software			
Gross margins training	✓	✓	
Farmer led on-farm data collection	✓	✓	
Orgware			
Water scheduling changes	✓		✓
Market linkages	✓	✓	✓

Source: Authors.

installation of tools on demonstration plots was also scaled up to the district level with soil moisture and nutrient monitoring tools being installed at four District Agricultural Centers of Excellence in Mhondoro-Ngezi, Chegutu, Insiza and Matobo (three of which are outside TISA's traditional districts). The tools were also installed at two research institutions that support the Centres of Excellence (Chibero Agricultural College and Matopos Research Station) through a project implemented by ICRISAT (Research Organization Stakeholder 1, pers. comm., 6 February 2023). A total of 986 soil moisture and nutrient monitoring tools have been installed in the three countries, with 754 irrigators on the VIA platform.

Learning through seeing and doing in all three countries further facilitated the scaling-deep dimension as irrigators changed some of the ways in which they traditionally practise agriculture and adopted new and innovative methods (see the section on sustaining impacts of scaling agricultural innovations at the regime level). The changes in agronomic practices included a decrease in the frequency and duration of irrigation events and fertilizer application, and growing higher value crops such as wheat, Irish potatoes and sugar beans (Government stakeholder 3). In Mozambique, for example, 64% of those irrigators utilizing the soil moisture and nutrient monitoring tools reported a reduction of irrigation frequency from 5 to 9 days on average. Ninety-three percent reported a reduction in irrigation events from 18 hours to 12 hours on average. The irrigators also highlighted other benefits, such as water saving, which was reported by 82%, time saving reported by 67.57% and labour saving reported by 55.41% of irrigators. For quantitative and detailed descriptions of the agronomic changes refer to Bjornlund et al. (2020), Chilundo et al. (2020), Mdemu et al. (2020) and Pittock et al. (2020).

The innovations were further scaled up from AIPs at both levels to district-level entities where scale bending occurred, including AIP members advocating for changes in water pricing (Pittock et al., 2017). From the district level the innovations were scaled up to provincial-level institutions where decisions around the issues were made. The innovations were further scaled up to the national level, where decisions around policy were made; at this level there was a need to scale down innovations for further implementation at the appropriate scale. An example is that of Zimbabwe, where entities such as the Department of Irrigation scaled the soil moisture and nutrient monitoring tools down to research entities and institutions for higher learning for further validation of their effectiveness to inform policy decisions on their use. After research and learning occurred

within research entities and institutions for higher learning the innovations were scaled up through the scale-jumping strategy back to the national level. From the national level the innovations were further scaled down through the provincial, district and right down to the irrigation scheme level, where some of the innovations were implemented within conducive institutional and policy environments created at higher levels. As demonstrated in the institution anchoring section, the Irrigation Department in Zimbabwe distributed and installed a total of 270 soil moisture and nutrient tools at 33 irrigation schemes across the country.

At high institutional levels, scaling mechanisms were crucial for scaling deep to occur within institutions responsible for policy decisions. Examples of scaling mechanisms utilized by TISA at these high levels included presentation of data from research-based learning and championing innovations through platforms such as the National Institute of Irrigation in Mozambique, the National Irrigation Commission in Tanzania and the Irrigation Working Group in Zimbabwe.

Sustaining impacts of scaling agricultural innovations at the regime level

The main aim for anchoring and scaling activities is to achieve positive impacts on the agricultural sociotechnical system of the targeted countries and to sustain benefits from the impacts. Over the period of project implementation, the sites where TISA has been implemented have experienced shocks such as the COVID-19 pandemic, droughts, flooding and related policy responses such as movement restrictions and water rationing that have had an impact on some of the gains from the scaled innovations. However, studies by Mdemu et al. (forthcoming), Moyo et al. (forthcoming) and Tafula et al. (forthcoming) indicate that the project recorded positive outcomes from the initial TISA1 and these were sustained and, in some cases, increased in TISA2 within the domains of field (scheme level), household, community and markets. Although TISA and non-TISA irrigation schemes were negatively affected by the shocks and policy changes mentioned above, it was established that irrigators and schemes supported by TISA demonstrated better adaptive capacity and resilience during these periods (Bjornlund et al., forthcoming). The research papers referred to above concluded that the use of the tools for decision-making and other agricultural innovations facilitated by AIPs have contributed towards the ability of these irrigation schemes to adapt and respond accordingly when faced with environmental, climatic and policy changes. Below are some examples of gains from the TISA project that were realized in TISA1 and sustained in TISA2. For a more detailed account refer to Mdemu et al. (forthcoming), Moyo et al. (forthcoming) and Tafula et al. (forthcoming).

Under the field domain, learning was characterized by high levels of farmer-to-farmer learning, where those without the tools learnt from the irrigators with the tools and mirrored the changes in practice. The behaviour change evidenced in those farmers without the tools could be attributed to social learning with a great likelihood that social networks played a vital role in this type of learning (Parry et al., 2020). Changes in irrigation practices included changes in irrigation frequency and duration and the number of syphons utilized by the irrigators. Only 20% of irrigators had the tools installed under TISA1; however, 35%, 62% and 60% of irrigators reported changes in irrigation practices in Mozambique, Tanzania and Zimbabwe, respectively. A survey in 2021 found that the

Table 4. Changes in irrigation practices under the TISA project.

Country	% Irrigators with changed irrigation practices (2013–17)	% Irrigators with changed irrigation practices (2013–21)
Mozambique (n = 40)	35	80
Tanzania (n = 54)	62	71
Zimbabwe (n = 59)	60	77

Sources: Mdemu et al. (forthcoming), Moyo et al. (forthcoming), and Tafula et al. (forthcoming).

percentage of farmers who changed their irrigation practices increased to 80% in Mozambique, 71% in Tanzania and 77% in Zimbabwe (see Table 4). It was also determined that irrigators who made changes during TISA1 continued to make further changes during TISA2. An example of changes made due to the installation of soil moisture and nutrient monitoring tools is that of Tanzania, where 78% of irrigators reduced the duration of each irrigation event by 2017; by 2021 there was an additional 6% resulting in 84% of irrigators having reduced the length of each irrigation event.

The household domain saw an increase in household food security compared to the four years prior to TISA1. In Zimbabwe, for example, 60% of irrigators attested to an increase in food security. This food security was sustained through TISA2 in all three countries with some disruptions to food security due to COVID-19 restrictions. Within the community domain, conflict over water decreased and survey participants also attested to their willingness to pay for water in TISA1 increasing and being maintained in TISA2. In Zimbabwe, 75% of farmers had increased their willingness to pay for water and of these 78% maintained this willingness through to TISA2. Under the market domain, there was an increase in the range of input sellers in TISA1; this was sustained and, in some countries, increased in TISA2. In Mozambique, 86% of irrigators attested to the range of input sellers increasing, and 43% perceived that there was an increase in TISA2.

Discussion

Over the years there has been increased concern over the influence of power dynamics in spaces that bring together diverse actors (Cullen et al., 2014; Opola et al., 2021; Swaans et al., 2013). For methodological and innovation anchoring to occur, AIPs need the collective capability to provide an environment that promotes inclusivity, respects diversity, manages disagreement and leverages power relationships (Wigboldus et al., 2023). Engaging the water authority as a stakeholder at the Silalatshani scheme level AIP led to the reduction of the water debt which would not have occurred without this more influential actor. Inclusive innovation and co-creation processes at the niche have in recent years been promoted as practices that ensure end-users of innovations are part of decision-making around appropriate innovations for them and their environment (Cullen et al., 2014; Heeks et al., 2014; Opola et al., 2021). The AIP innovation process enabled irrigators to determine the innovations that were prioritized by the AIP and scaled to different levels. Their engagement at this level enhanced ownership and drove them to champion the innovations that subsequently promoted scaling and adoption. Irrigators who are AIP members attested to championing innovations initiated by AIPs at scheme-level meetings and in normal discussions with other irrigators. Building the capacity of

local stakeholders to innovate and scale also ensured that the innovations were embedded within local institutions, sustained and adapted to suit the prevailing environment.

When innovations leave the niche, they are introduced into the regime environment that is set in its ways; without innovation champions, the innovations may be rejected and not go to scale – this is where the collective capability to relate and partner for network anchoring becomes critical (Polita & Madureira, 2021; Wigboldus et al., 2023). AIPs under TISA leveraged networks at different levels to facilitate information sharing and to effectively scale innovations including those within the AIP and those already established local institutions, traditional/community leadership, development partners and agricultural research institutions to not only extend their geographical reach but to also promote their institutionalization. AIPs were also able to leverage new partnerships with the private sector, which is a newer paradigm that has been promoted by international organizations such as the International Fund for Agricultural Development (IFAD) through private-sector engagement strategies (IFAD, 2019).

Although there has been increased concern and global resistance against top-down governance approaches due to experiences with traditional extension methods, there are cases where these are required for innovations to be implemented and adopted at the appropriate level (Chester, 2005; Seifu et al., 2020). The multidimensional, multistakeholder and multilevel characteristics of the environments where innovations are scaled require that a mix of bottom-up and top-down approaches to scaling agricultural innovations be utilized to ensure institutional anchoring for successful scaling of the innovations (Wigboldus et al., 2023). For this to occur, the AIPs require the capacity to stimulate policy alignment and integration (Wigboldus et al., 2023), Figure 3 demonstrates how TISA AIPs utilized this mixed approach with some innovations such as the installation of the soil moisture and nutrient monitoring tools being scaled up from the AIP to the national level utilizing the bottom-up approach in Zimbabwe. Upon institutionalization at the national level, the tools were scaled down utilizing the top-down approach for institutionalization at irrigation schemes at the local level across the country, with a far wider reach than could have been facilitated by the AIPs.

Once anchoring has occurred, actors within the niche need to continuously explore new ways of linking the niche to the regime until those practices or innovations promoted at the niche level become a regime component (Seifu et al., 2020). AIPs under TISA utilized different scaling dimensions as illustrated in Figure 3 to ensure that the innovations were embedded within irrigation schemes and entities at district, provincial and national level. Scaling dimensions utilized under TISA can be replicated and transferred for use in other geographical locations. However, scaling efforts should take into account the varying geographical, governance, stakeholder, power and political dynamics (Gebreyes et al., 2021; Ingram, 2015). AIPs under TISA utilized scaling strategies to adapt its scaling endeavour to these varying characteristics. It is important to also note that because scaling strategies are utilized as an adaptive method they will look different at each geographical location. Although scaling mechanisms discussed in this paper can be replicated in other areas, they may not all be appropriate for new locations; it is therefore important that those involved in scaling endeavours select the most appropriate scaling mechanisms for their locations.

Scaling of single innovations is a rare phenomenon, as innovations are normally spread out as selected innovation packages of core and complementary innovations (Sartas et al., 2020). Complementary innovations are normally those that are scaled to create enabling environments at different levels for the adoption of the core innovations (Sartas et al., 2020). This is evidenced in TISA, where core innovations, such as the installation of soil moisture and nutrient monitoring tools and market engagements, were scaled in conjunction with on-farm data collection, gross margins training and changes in cropping calendars. The benefits of scaling such a package are that irrigators were able to provide evidence of their reduced water use through documenting irrigation events; they were also able to assess the profitability of the new agronomic practices, the introduction of crops previously not on the cropping calendar and increased market access through gross margins calculations. Irrigators were therefore able to make decisions on the continued use of innovations based on evidence – it is this evidence that also informed adoption choices at other levels of governance (see van Rooyen et al., 2020, for comprehensive systemic changes in Zimbabwe). It is important to recognize that scaling is a means to an end; those leading scaling endeavours should continuously monitor projects to ensure that the process has positive livelihood impacts and that these are sustained for continued benefits to end users.

There is a general consensus that the niche level is a space for path-breaking innovation, where innovation, co-creation and experimentation can occur with limited external disruption (Hermans et al., 2017; Seifu et al., 2020; Smith et al., 2010; Totin et al., 2020; Wigboldus & Brouwers, 2016). However, the continued need of niche spaces such as AIPs is a contested area (Makini et al., 2013). We argue that after developing the collective capabilities suggested by Wigboldus et al. (2023), AIPs can be integrated into already existing local structures for long-term benefits guided by the following conditions: (i) they have yielded positive innovation and scaling results, (ii) they have strengthened the capacity of members to innovate within and outside the forum, (iii) the continued exposure of the value chain to natural and man-made shocks and related policy changes, and (iv) the ability of the AIP to evolve to provide solutions to emerging challenges and/or support the management of scaling outcomes. The high establishment costs of AIPs are usually supported by external funding, it has been argued that long-term financial support can diminish member ownership of the platforms and processes as members are not responsible for the cost of investment (Faysse, 2006; Schut et al., 2019). This paper suggests that methodological anchoring through the integration of AIPs into already existing structures led by local facilitators with closer proximity to AIP sites is a viable and effective method for cutting down on costs of establishing and maintaining the forums while achieving long-term benefits.

Conclusion

This paper contributes to agricultural transition and scaling literature by: (i) exploring how AIPs can be utilized to anchor and scale agricultural innovations from the niche level to effect changes within the sociotechnical regime; (ii) determining scaling approaches utilized by the TISA project and making recommendations for replication and transfer of the approaches; and (iii) determining how impacts of scaled innovations were sustained. The paper determines that the research team has a role to play

in initial methodological anchoring of the AIP process. The paper suggests that for AIP initiated innovations to successfully scale, they need to initially anchor into the niche before linking to the regime. The right mix of stakeholders is critical in facilitating innovation linkages to the appropriate governance level for positive scaling impacts. As demonstrated in this paper, AIPs that have developed relevant collective capabilities can be instrumental in innovation and scaling agricultural innovations; however, the paper suggests that their continued use should be based on the criteria discussed in the preceding section with integration of the AIP in existing local-level structures led by local facilitators. The paper also argues that not all systemic challenges require the formation of new AIPs – already existing AIPs can be utilized for scaling to new geographical contexts.

Although scaling is a dynamic process that cannot be fully planned for, this paper recommends that for scaling to be effective it has to be integrated into a project's proposal and theory of change. Scaling dimensions identified under the TISA project can be replicated in other geographical areas; however, this paper recommends that scaling strategies be utilized to adapt scaling approaches to differing contextual dynamics – these will be unique to each location. Scaling mechanisms facilitate the acquisition of information and evidence required to make decisions around adoption of innovations at different levels; the scaling mechanisms in this paper will not be appropriate to every context and a selection of the most relevant will need to be done. To sustain scaling impacts for long-term benefits, there needs to be an investment into collective capabilities of AIPs to co-create, innovate, anchor and scale.

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