

Anticipating gender impacts in scaling innovations for agriculture: Insights from the literature

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ABSTRACT

Of the world's 570 million farmers, 72% work on two hectares or less, and women's labor comprises at least 50% (FAO, 2014). Small farms are responsible for 80% of world food production, making them key to addressing looming global food shortages (Lowder et al., 2016). Small farms in developing countries navigate a myriad of challenges, including access to information, quality inputs, capital, markets, and among others, land (FAO, 2014). These challenges can be exacerbated for women and other marginalized groups of people due to social norms within their communities (Petesch, Badstue, & Prain, 2018; Polar et al., 2017; Rola-Rubzen et al., 2020). Inclusive innovation to address agriculture productivity and loss gaps is tantamount to equitable global food security (FAO, 2014; FAO, 2011). However, many innovations still fail to help stimulate disruption in gender or social inequities, and some even do additional harm. Increasing use of an innovation, referred to as 'scaling,' is critical to impact at a community or regional level, and is often seen as necessary to support Agriculture Research for Development (AR4D) outcomes (Sartas et al., 2020). Several scaling support tools and methodologies have been developed to assist researchers and practitioners in scaling processes. However, little practical attention has been given to the specific cross-section of gender and relevant diversity within scaling tools and methodologies.

This narrative literature review begins to address this by answering: 1) What are unique gender considerations when scaling agricultural innovations?; and 2) What are appropriate methods and approaches for collecting data on these unique gender considerations? Our review finds six points of attention to reflect upon unique gender considerations when innovating and scaling innovation: i) Comprising research and project teams, ii) Designing agricultural innovations, iii) Communicating and extension of innovation, iv) Choosing scale models: entrepreneurship and business development, v) Reinventing and changing technology, and vi) Engaging with the political economy of innovation. Methods to collect necessary data to accurately reflect on these considerations and avoid unintended negative consequences for more gender responsible scaling are also presented. Finally, the literature review is situated in a perspective that more attention should be given to agricultural innovation and scaling support tools and methodologies to address gender or socially marginalized groups.

Of the world's 570 million farmers, 72% work on two hectares or less, and women's labor comprises at least 50% (FAO, 2014). Small farms are responsible for 80% of world food production, making them key to addressing looming global food shortages (Lowder et al., 2016). In poorer countries, crop yields per hectare are up to 76% less than in more affluent countries, and postharvest losses are estimated at 40% (FAO, 2014; Blakeney, 2019). Small farms in developing countries

navigate a myriad of challenges, including access to information, quality inputs, capital, markets, and among others, land (FAO, 2014). These challenges can be exacerbated for women and other marginalized groups of people due to social norms within their communities (Petesch, Badstue, & Prain, 2018; Polar et al., 2017; Rola-Rubzen et al., 2020). Inclusive innovation to address these gaps in agricultural production and loss is tantamount to equitable global food security (FAO,

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2014; FAO, 2011).

Increasing use of an innovation, referred to as ‘scaling,’ is critical to impact at a community or regional level and is often seen as necessary to support Agriculture Research for Development (AR4D) outcomes (Sartas et al., 2020). To support effective AR4D outcomes more international attention has been given to the science of scaling. As a result, scaling support tools and methodologies for researchers and practitioners have been developed (Sánchez Rodríguez et al., 2020). The concept of ‘responsible scaling’ has also emerged in various forms as a responsive scaling process that addresses social inequities within AR4D (Schut et al., 2020). Still, many ‘scaled’ innovations fail to successfully stimulate disruption in gender or social inequities, and some even do additional harm (de Roo et al., 2019). To achieve Sustainable Development Goals concerning hunger and social empowerment, more practical attention must be given to the specific cross-section of gender and relevant diversity within scaling support tools and methodologies.

To address this, we glean insight from the literature to answer these questions: 1) What are unique gender considerations when scaling agricultural innovations? And 2) What are appropriate methods and approaches for collecting data on these unique gender considerations? This paper begins with an introduction and conceptual framework to consider where and how these unique gender considerations interact within concepts of scaling. This is followed by the methods used for our narrative literature review. In Section I we present findings of unique gender considerations and anticipatory questions. Section II presents methods to collect data to answer the anticipatory questions accurately. We conclude with a perspective on implications for development programs and a call for more attention to gender-responsive scaling support tools and methodologies.

1. Introduction

Gender equity and social status dramatically influence innovation and scaling processes (Shibata, Cardey, & Dorward, 2020; Petesch, Badstue, & Prain, 2018). Rates of adoption among women and marginalized populations are often lower than those for men (FAO, 2011). Lack of access to resources such as land, financial credit and capital, social capital and networks, and agriculture information are often the cause of lower rates of innovation used by women (Rola-Rubzen et al., 2020; Tanellari et al., 2014). Further, systemic issues impact innovation development (e.g., technology designed for men), cultural perception of women’s roles (e.g., machinery run by men), and discrepancies in access to high-end technology (e.g., Information Communication Technology controlled by the male head of household) (Ragasa, 2012). These apparent differences in how women and men and those with less social power interact with innovations warrant special attention and development (Rietveld and van der Burg, 2021).

Farmers and regional stakeholders vary considerably - both agro-ecologically and socio-culturally - generating a complicated heterogeneous landscape. Social groups can differ along many dimensions, such as wealth, employment, or religion, and play a role in shaping the effects and distribution of an innovation’s benefits (Hammond et al., 2020). Gender is a critical dimension because it cuts across almost all other social groups, creating unique experiences for women and men within the same social group (Farnworth et al., 2018). Implications of this intersectionality are particularly crucial when assessing or anticipating an innovation’s impact on marginalized communities (de Roo et al., 2019). AR4D projects’ interventions to these sub-groups often fall short due to unforeseen indirect or direct issues with the innovation – or worse, do harm to certain groups of people (Galiè et al., 2017).

Avoiding, as best possible, these unintended consequences requires scaling processes to understand, navigate and reflect complex local and regional landscapes (Gebreyes et al., 2021). Academics and practitioners have developed several scaling support tools and methodologies, such as the Agriculture Scaling Assessment Tool (ASAT), Scaling Readiness, and PRactice-Oriented Multi-level perspective on Innovation and Scaling

(PROMIS), to help address scaling in these complex environments (Sartas et al., 2020; Wigboldus et al., 2016; USAID, 2018). These resources are delivered as tools for research and project teams to develop more successful scaling strategies, generally focused on already developed innovations and overcoming limiting factors within the scaling landscape.

The International Maize and Wheat Improvement Center (CIMMYT) Scaling Scan Tool aims to account for social implications within complex environments by including a “responsibility check,” which asks whether or not women and men, or marginalized communities will benefit equally from an innovation (Jacobs et al., 2021). However, the Scaling Scan scope does not include guidance and sensitization for researchers, practitioners, or communities to creditably understand and respond to these questions. For instance, a team without a gender expert or community member may not ‘correctly’ answer these questions. Other, more data collection focused tools, such as GENNOVATE, look deeply at gender normatives and their impact on accessing the benefits of an agricultural innovation, and the Women’s Empowerment in Agriculture Index quantifies regional landscapes of women’s empowerment (Alkire et al., 2013; Petesch, Badstue, & Prain, 2018). While these tools are critical to understanding the local normative climate across regions, they do not address gender and intersectionality implications in specific scaling processes.

This paper adds to this discussion to provide decision support to effectively scale agricultural innovations, avoid unintended gendered consequences, and support positive development outcomes. We hope these findings will stand as an inspiration for developing gender responsible scaling tools and methodologies.

2. Conceptual framework, Figure 1

Scaling and scaling processes: Scaling refers to the use of an innovation outside its original design team (Sartas et al., 2020). In international agriculture development, the goal of scaling is usually to increase the use of an innovation, and by doing so, create a positive social benefit or outcome (Schut et al., 2020). These goals might include “increased farmers’ income” or “increased regenerative agriculture practices.” In scaling processes there are different considerations, such as research and development, pilot testing and assessment, training and dissemination, models for continued growth (such as private entity or government promotion), and iterative, adapted versions of the innovation. Scaling processes are not linear and engage dynamically with the external environment; both the innovation and the external environment are constantly re-negotiating and changing as a result of the other (Glover et al., 2016). Scaling processes are demonstrated at the middle of the conceptual framework. Along with how an innovation is initially developed, scaling processes are where researchers, practitioners, and communities have the most agency to change how an innovation will impact (or not) the external environment.

External environment: The external environment is what the innovation aims to disrupt in some way. This disruption could, for instance, increase farmers’ income through new on-farm machinery or improve women’s nutritional health through home gardens. The external environment provides the local normative context and enabling environment that an innovation is scaled within and reflects (Petesch, Bullock, et al., 2018). This is where we better understand, for instance, who has access to resources, what is considered culturally appropriate for social groups, and what policies support (or not) equitable landscapes. Throughout scaling processes, the external environment will influence how the innovation is used, by who, and groups of users that benefit or do not. This is represented on the left-hand side of the conceptual framework.

Core and complementary innovations: Core innovations are those that scaling processes are centered around and meant to disrupt the external environment, usually toward a social goal. A core innovation might be a new savings group developed to increase access to capital for

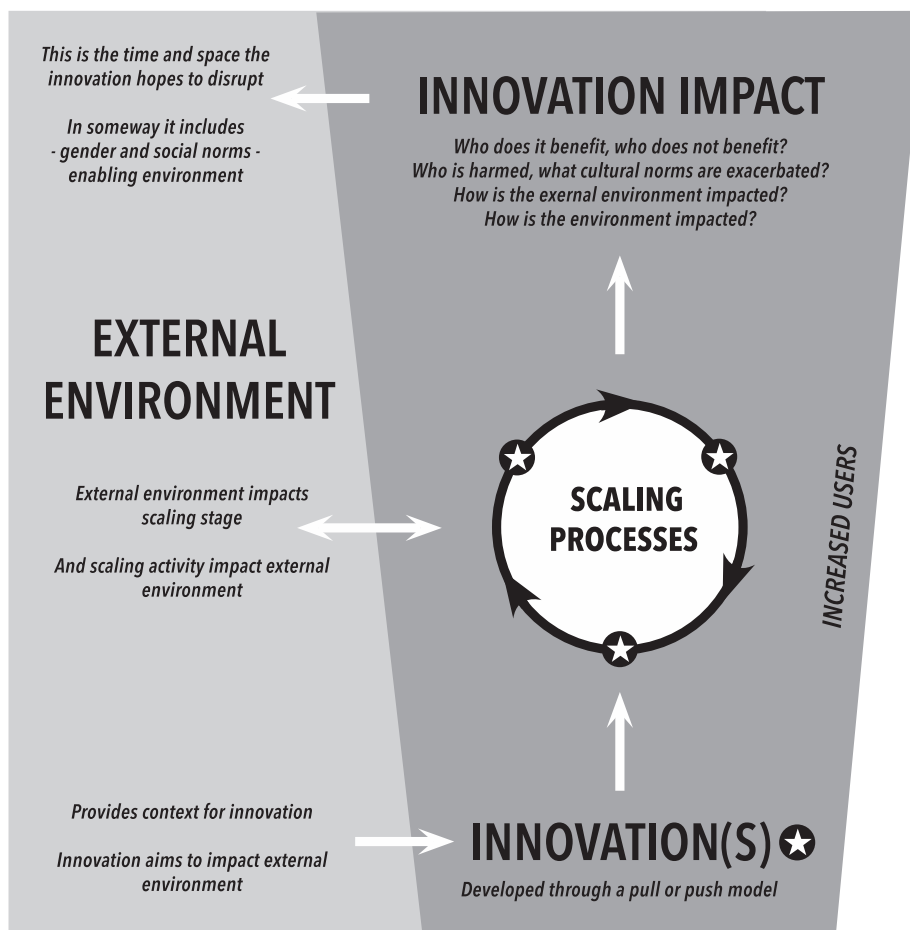


Fig. 1. Conceptual framework – Anticipating gender impacts in scaling innovations.

low-income women. Complimentary innovations are developed before and during a scaling process to ensure that a group of people can successfully use and benefit from a core innovation being introduced. They are meant to reflect and change the external environment and provide additional support to focus populations. Examples of complementary innovations are financial management training or savings instruments, which allow the focus population, low-income women, to access the benefit of savings groups, the core innovation. Together, these innovations are often represented as “innovation packages” being scaled, represented at the base of the conceptual framework. Core and complementary innovations are not discussed at length in this paper but are conceptually included to provide context and intention for the anticipatory questions (Sartas et al. 2020 provide an in-depth description).

Push and pull scaling: Innovations can be scaled through either a push or pull model, or a combination of both (Totin et al., 2020). A push model is when a researcher, practitioner, entrepreneur, or community has an innovation in hand and believes it has beneficial use within a spatial and temporal context (Wigboldus et al., 2016). A pull model identifies a social challenge, and an enabling environment along with innovation packages are developed to meet that challenge (Wigboldus et al., 2016). These two different starting points must be considered, in the first, the innovation is already developed, and in the second, the innovation is developed to address a particular social outcome. While both are vulnerable to unintended consequences, more effort may be needed to develop complementary innovations to mitigate a push model’s lack of initial design for social disruption. In a pull model, particularly if equity goals are prioritized initially, the innovation’s benefit may be more likely to be equally distributed. However, careful thought should still be given to how the innovation may change or

control over it may change as it moves through scaling processes. The push and pull scaling methods are essential to note, as researchers, practitioners, and community members may interpret the unique gender considerations and anticipatory questions differently, one with an emphasis on developing mitigating and complimentary innovation and the other to adjust the core innovation itself. This decision point is represented at the base of the conceptual framework.

Innovation users: In the process of scaling, the use of the innovation directly or indirectly impacts individuals (users and non-users), communities, and landscapes of the external environment. How different groups benefit or not from the scaling of a particular innovation depends on a range of factors such as people’s roles in their household and community, their labor tasks, the nature of their agricultural systems, cultural contexts, access and control over materials, human and social resources, values and aspirations, and the ability to make choices. As noted previously, gender is a dimension of diversity that is especially important because it intersects with almost all other dimensions. It is important in the scaling process to identify relevant dimensions of diversity to develop innovation packages appropriately.

Unique gender considerations: Section I highlights factors found consistently in the literature that contributed to positive or negative impacts for women, as they relate to other relevant diversity. These considerations are unique because they are generated from the perspective of non-dominant archetypes within a community. Due to women’s marginalization and lower positions of power, *intentionality* in addressing their unique situations is required to understand how they will be impacted (Petesch, Badstue, & Prain, 2018).

Thus, these unique gender considerations are pulled from the literature to be considered within scaling processes to avoid unintended

consequences or reach for aspirational social outcomes. Where the unique gender considerations meet practical application are identified by stars in the conceptual framework.

At these points –

- We should ask anticipatory questions about the innovation's effect on users and non-users, and the ripple effect within their community and landscape.
- Greater inequity can be created or abated. These points are not the only places that inequities can be pacified or exacerbated but are functional areas to pause, reflect, and potentially take action.
- The considerations will be different depending on the relevant diversity of innovation users and non-users.

Anticipatory questions: These questions are only as helpful as the discussion and answers they invoke. Developing insightful and impactful discussion, and ultimately avoiding unintended consequences or developing positive social disruption, depends heavily on who responds to the questions. This is addressed under 'Comprising research and project teams' below but deserves emphasis in the conceptual framework, as these questions offer no real insight if they cannot be answered in a manner that truly reflects the cultural landscape and needs and wants of intended users or those indirectly impacted. Thus appropriate diversity and contribution within teams such as gender and bio-physical experts and those with intimate knowledge of the initial scaling region are important (none are necessarily mutually exclusive). Additionally, at crucial junctures, a team must realize they need more information and know where and how to collect it. Section II highlights validated methods to collect more information if needed.

Avoiding negative consequences: The unique gender considerations and anticipatory questions are meant to help researchers, practitioners, and communities think through how their innovations might unintentionally harm a group of people or miss the mark in achieving a social equity goal. As highlighted in Section I, these unintended consequences happen frequently. Unless an innovation is disruptive to social power structures within an external environment, it can re-affirm embedded structural inequities.

This tension gets at some of the core questions for gender responsible scaling: Can an innovation not designed initially with social equity in mind be socially disruptive? If it cannot be, can we mitigate its consequences, and at the very least, do no harm? If the innovation successfully scales within a particular context and thus ultimately re-affirms harmful gender norms, is scaling the innovation still worth the pursuit? What are the trade-offs within the community? Who decides if those trade-offs are worth the further marginalization of some social groups? A difficult reality for some researchers or practitioners with a certain set of expectations for an innovation is that doing no harm can be more complicated than it seems.

Additionally, trade-offs not only occur when developing or introducing an innovation, but they also occur as the innovation changes within an external landscape (and vice versa), over time, and at different scales. Who has power over the innovation and the benefits of the innovation changes over time. An innovation that successfully secures more income for women in the short run might prove to be so successful that men take it over – because gender constructs around decision-making power are not addressed. However, in this same example, while women may be relegated back to their previous low-earning potential when men take over, their families may be better off because of the increased overall family income. This in turn allows both sons and daughters to attend school. Over time, this secondary outcome could ultimately realize long-term positive impacts for the girls who can now attain an education. Calculating social benefits for the individual versus community, short-term versus long-term, and local versus regional is difficult. These complicated trade-offs are why it is crucial to have diverse expertise and regional innovation users as a part of the innovation design and scaling process. Ultimately deciding on these trade-

offs as an external agent without diverse regional input is reason to expect unintended consequences.

By more deeply understanding possible social trade-offs we hope the provided anticipatory questions contribute to more thoughtful, gender-responsible and responsive scaling. Through identifying areas of particular concern in the scaling process, innovation developers and promoters can use anticipatory assessment methods to avoid a range of potential negative impacts. Instead, alliances, systems, and strategies can be built to mitigate unintended consequences and achieve overall positive social outcomes.

3. Methods

3.1. Literature review

Publications were sourced through google scholar, Scopus, and Web of Science. Relevant literature was found using several methods: 1) Using a combination of key terms, including agriculture research for development, gender, women, and scaling; 2) A cited reference expansion of the search; 3) References in major government, universities, and NGO reports by relevant actors, such as Stanford's Gendered Innovations group and the United States Agency for International Development; and 4) Articles suggested by gender experts within the Consultative Group for International Agricultural Research (CGIAR).

The articles reviewed included development theory, scaling and diffusion, responsible research and innovation, human and physical geography, and economics – which often involved feminist critiques or case studies of unintended consequences. Ex-ante models and anticipatory literature and methods, such as focus groups and participatory design, were also reviewed to understand practical steps to better predict and mitigate unintended consequences. Priority was given to papers if they were published from 2000 to 2020. However, fundamental theories or methods that might offer insight into unique gender considerations or predict negative outcomes were considered.

3.2. Document analysis

Our research questions provided the framework in which literature was analyzed, categorized, and coded to highlight emerging unique gender considerations and anticipatory methods to address them. This analysis also was used to identify where further research is needed. Articles were coded and organized by theme through an inductive approach using NVivo (released in March 2020). Articles were first coded in broad themes, such as communication, access to resources, ex-ante analysis, and the type of research method, such as case study or randomized control trial. Documents were also coded into binary categories that separated from potential gender consideration and ex-ante predicting methods. Further, papers were coded for stages within the innovation cycle, such as innovation development or scaling activities. Finally, a second list of codes was developed by looking at the range of coded literature, capturing emerging gender themes, which allowed us to code for a series of unique gender considerations.

3.3. Section II: Findings: unique gender considerations and anticipatory questions

Six points of attention to reflect upon unique gender considerations highlight insights that were found consistently in the literature that contributed to positive or negative impacts for women, as they relate to other relevant diversity. The points of attention highlighted reflect moments within scaling processes that innovation teams can pause, reflect, and act (see conceptual framework). These unique gender considerations are not all encompassing of challenges within each category, but what can be intentionally considered when thinking of gender. For instance, in the category "comprising research and project teams," we discuss methods to encourage more dynamic input from diverse staff -

not general team dynamics or methods that might influence scaling at large. Each point is summarized with examples from available research, and then anticipatory questions follow to help guide insightful discussion among innovation teams.

i. Comprising research and project teams: Gender and power bias do not begin in the field; these biases are systemic and prevalent throughout innovation and scaling systems (Ragasa, 2012). From the Global North to the Global South, men are more often in leadership positions (Georgieva, 2020). Although underrepresented groups, such as women and non-white men, innovate at similar or greater rates than their white male counterparts, their contributions are less likely to be taken up by their peers (Hofstra et al., 2020; BenYishay et al., 2020). This is true even though the individual diversity of team members in innovation systems has been shown to consistently contribute to positive AR4D outcomes (Wigboldus et al., 2016) and in the broader network and innovation literature (Bell et al., 2011; Burt, 2004). Nielsen et al. (2017) find that diverse research teams more frequently develop dynamic and unique solutions, and as a result, produce successful development outcomes. This is achieved through including more bottom-up approaches that are less prescriptive, identifying and using team expertise, and disaggregating sex data (Nielsen et al., 2017).

Research and project teams can enable environments that utilize diverse expertise by establishing more horizontal management structures (where ideas can more equitably percolate up), supporting a critical mass of diversity, and encouraging new ideas, even when against the status quo (Cain & Leahey, 2014; Nishii, 2013). Neilsen et al. (2017) close with, “carefully designed policies and dedicated leadership allow scientific organizations to harness the power of gender diversity for collective innovations and discoveries” (p. 1742). If agriculture innovation and scaling teams are not built to address the focus populations they aim to serve, interventions may not be successful.

Anticipatory questions: Who is leading the project? How does their positionality and the members of their team impact future decision-making? What capacity building needs to be done to ensure project team members are aware of their limitations and contribute to a more gender and power-conscious project? What are areas where a project (or project team) may lack expertise or awareness? Who is in the project team’s network that might cause the exclusion of others? What political ties are relevant that might prevent critical systems change from occurring? With whom did the project partner?

ii. Designing agricultural innovations for women: Often, agricultural innovations are designed with non-disabled men in mind (Polar et al., 2017). Moreover, while women can innovate at the same capacity as men in the field, they are often limited by external inputs and social networks (Badstue et al., 2018). As a result, innovations such as machinery can be too burdensome or not culturally appropriate for women and other marginalized populations. Kawarazuka et al. (2018) present several examples where interventions failed to deliver development outcomes due to a lack of communication with potential women users in the design stage, consideration of cultural and physical appropriateness, and labor demands on both men and women. In one example from Peru, researchers introduced solar-drying technology to women who were happy with the current practices of sun drying and actually desired technology that peeled (rather than dried) potatoes (Kawarazuka et al., 2018). In another example from Uganda, a silage chopping machine was introduced to reduce drudgery and decrease labor hours for women. However, the focus population perceived the machine as too challenging to operate. This ultimately led to a dependence on men who owned and operated the machines (Kawarazuka et al., 2018).

Kansanga et al. (2019) find that new mechanized technologies in Northern Ghana reduced demand on men’s labor, enabling them to expand crop cultivation. However, the same technology raised the labor demand on women’s gender-ascribed roles of sowing and weeding. Similarly, the adoption of new upland rice varieties is described by Bergman Lodin et al. (2012) to have an overall positive effect on household economic status. However, it exacerbated the workload of

women and children in their tasks of bird-scaring and weeding. Ultimately, in both situations, while men benefited overall, women were negatively impacted by the innovation use (Kansanga et al., 2019).

It is often at the intersection of gender and other social factors that the most significant disadvantages or inequalities are created. For instance, Rietveld and van der Burg (2021) describe how age intersects with gender in constraining young women from participating in commercial agriculture in Central Uganda. Kawarazuka et al. (2018) describe how women from ethnic minorities in Vietnam are more likely to be deprived of access to the benefits of hybrid rice varieties due to this intersectionality. Marital status is often an important factor influencing women’s ability to engage with and benefit from innovation processes. Widows often have more decision-making power and control over resources in their household than married women, and normative ideas about what women can and cannot do tend to be less strict for widows (Petesch, Badstue, & Prain, 2018). However, widows might often be constrained in terms of access to resources such as labor or land.

Anticipatory questions: What focus population was the innovation developed for? How likely is it that the focus population will be able to articulate its needs and demands? How likely is it that the focus population will be able to physically operate and culturally use it? What systems of labor will be disrupted? Does the focus population usually have decision-making power over the system the intervention targets?

iii. Communicating and extension of innovation: While farmer-to-farmer programs and extension services are generally accepted as essential methods of information diffusions, they may not be as equally of service to women. Norton and Alwang (2020) note that for years, agriculture productivity suffered because of gender bias. More extension services function with greater gender balance in recent years, but there are still significant discrepancies, and different approaches are needed to realize equal focus and access among women (Kristjanson et al., 2017; Quisumbing et al., 2014). Through experiments with extension videos on improved maize management in Uganda, Lecoutere et al. (2019) show that providing women direct access to extension information results in significant advances in women’s roles in maize production and sales. Structurally, Rola-Rubzen et al. (2020) note that the objectives of extension programs are often to increase production rather than complementary skills needed to utilize innovations, which women often lack and are systematically excluded. Thus more attention should be given to complementary skill sets so that women can access the benefits of core innovation.

Perception of innovations varies depending on the gender of the communicator. BenYishay et al. (2020) conducted a field experiment across 143 Malawian villages where men and women were taught a new practice and then charged with communicating it to their peers. The author’s results showed that both men and women farmers are less willing to learn from female communicators, whom community members perceive to be less knowledgeable about agriculture and technology than their male counterparts. The authors believed this is due to social norms, such as ‘women should not teach about farming’, or that ‘men do not like to talk to women about farming’. Or generally, women not being trusted thought leaders (BenYishay et al., 2020).

ICTs are playing an increasing role in extension services. The World Bank (2017) notes that men and women equally are willing to use cell phone technology. However, access to ICTs can be limited for women, and men are globally more likely to own a phone (84% compared to 74%) and in some countries, such as Pakistan, are more than twice as likely to own a phone (World Bank, 2017). With many extension programs leaning into mobile phones as providers of information, access and literacy to this innovation are important to understand (Peterman et al., 2011).

Anticipatory questions: What extension information dissemination requirements are associated with using this innovation? If this innovation is brought to scale, who will communicate about the innovation and use it in the field? What will be the platform for information dissemination, and does the focus population have access to it?

iv. Choosing scale models: Entrepreneurship and business development: Many development interventions promote for-profit models for innovation adoption and use after project funding is removed. And many donors have emphasized “returns on investment” or “outcome investing” as markers for innovations that make good candidates for resource allocation and scaling (Masters et al., 1998; Renkow and Byerlee, 2010; Glover et al., 2016). However, vulnerable populations may not necessarily profit or utilize innovations the same way as socially advantaged populations (Bullock and Tegbaru, 2019). While one innovation might be profitable and make sense for those with social power, it may not have the same outcomes for women or other socially marginalized groups.

Evidence from Greater Gaborone in Botswana highlights discrepancies in outcomes of agribusinesses in urban agriculture. Although peri-urban food businesses have been heralded as significant economic and nutrition drivers, Hovorka (2005) found that individuals’ socio-economic status, location, and human-environment interactions significantly differed along gender lines and, as a result, shaped their productivity within the sector. Even with the financial capital provided to low-income women to start food businesses, low-income men could secure better land and markets, making them more profitable and sustainable.

Disaggregation among a focus group or region plays a significant role in understanding if women can access the benefits of innovation. In the Mekong Delta, Paris and Chi (2005) found that plastic drum seeders benefitted better-off households but ultimately resulted in the loss of livelihoods for women from more impoverished and landless households who used to be hired to undertake these tasks. Almekinders et al. (2019) discusses the need to better understand heterogeneity within a landscape when researching the potential impacts of new seed varieties in a single community. Farmers with fewer resources are more risk-averse, have fewer resources to use the innovation, and cannot re-invest any additional profit as their better off peers (Almekinders et al., 2019).

Ragasa (2012) conducted a literature review of 35 case studies considering women and technology adoption. The author consistently found that low adoption rates were mainly due to differentiated access to complementary inputs and services. Understanding the resource context in which innovation is introduced is critical to a realistic adoption expectation and sustainable scaling models, especially among women and vulnerable populations (Polar et al., 2017). Without considering these factors different ‘business model’ scaling strategies can re-affirm disparity in class structures.

Anticipatory questions: Researchers and practitioners may need to consider other complementary innovations or policies to address inequities. Does the focus group have the necessary complementary inputs to use the innovation? Will the focus group control those inputs? For example, does this innovation depend on accessing credit? How likely is it that women can access credit in context? What are the necessary social and physical inputs for the business to be profitable?

v. Reinventing and changing technology: While many frameworks and evaluator approaches measure adoption as a single, binary transaction where a farmer chooses to adopt or not, there is a growing theoretical body that posits adoption is a much more complicated process (Schut et al., 2016; Wigboldus et al., 2016). Within this literature, there is an increased focus on how innovation changes within the system it is operated (Crane, 2014; Jansen & Vellema, 2011) – and the importance of innovation to be adapted and reinvented to scale successfully (Glover et al., 2019). Glover et al. (2016) comment that “*technology is something people do, make or remake, not something they receive to adopt*” (p. 4). Glover et al. (2019) further this concept by identifying that technology adoption not only involves morphed versions of the initially introduced technology but a reconfiguration of relations among people, redistribution of agency, reformation of institutional arrangements, and acquisition of new skills and practices.

For example, Coe et al. (2014) found that conservation agriculture packages for agroforestry in Africa ultimately failed in many places

because it was too prescriptive and unable to adapt to local context and conditions. Evidence from where conservation agriculture methods were successfully applied showed that producers could change the technology for their individual needs. While this can be a positive attribute of an innovation system, this flexibility at the local level can also work against marginalized populations. Fisher et al. (2000) found that the successful scaling of a dairy technique aimed at Senegalese women to improve milk production and profits, was eventually transformed into an activity led by men. Other research by Bishop-Sambrook (2016) show that upgraded transport, such as donkey carts or bicycles, often falls under the control of men or adds more unwanted responsibilities for women compared to when they were less mobile.

While more research is needed in this area, if focus populations do not have the social capital or expertise to contribute to these complicated systems of re-invention or own them, then the innovation can be re-appropriated by and for a different population, potentially even adversely impacting the focus group.

Anticipatory questions: How will the innovation be reinvented after introduction in the field? Will the focus group have access and input into re-invention? Does the innovation mean to be used as it arrives? What populations most likely will interact and reinvent the innovation once in the field? What groups or individuals will impact future iteration, and what access to participation does the focus group have? What are the effects on local labor markets? How will (are) intra-household labor arrangements be affected?

vi. Engaging with the political economy of innovation: The broader political environment is often not recognized when thinking through innovation scaling pathways. Or maybe better described, are avoided, when assessing the potential positive impact of an innovation within a community. Additionally, the enabling environment is an important concept in scaling literature that describes the appropriate conditions for an innovation to be scaled (Houkonnou et al., 2018). Enabling conditions include the political economy, and can include all-encompassing economic and social institutions, such as capitalism, to entities that stakeholders will likely occupy and have an impact on, such as universities, NGOs, donors, and government agencies. Enabling conditions can also include cultural institutions that can significantly impact access that certain populations will have to an innovation (Schut et al., 2016). Often these broader environments are considered too difficult to change or politically unappetizing to approach.

Schut et al. (2016) consider this question within the context of ‘innovation platforms,’ facilitating interaction between multi-level stakeholders for institutional change. Niche-regime theory was used to understand challenges and anticipate how to manage them – and whether or not certain institutions facilitate or hinder technologies that depend social norms. The authors conclude that significant paradigm shifts are necessary to address systemic issues within institutions that often underscore the power of already powerful actors. Acosta et al. (2019) look more granularly into the reasons for this and found that neglecting gender discourse and gender inertia, shrinking gender norms, and minimizing budgets prevented positive gender transformation policy space. They found that encouraging women’s movements and closer monitoring of policy implementation facilitated better outcomes for women.

Partnership is critical to enable a dynamic scaling path, particularly when there are different levels of expertise, political connections, and positionality. Multi-stakeholder platforms and network analysis have underscored the importance of multi- and intra-disciplinary and multi-level organizations within a system of change (Klerkx et al., 2010). In these more decentralized systems, there is greater knowledge exchange, incubation for innovation, and community adoption of innovation – and increased functional capacities, such as diversified leadership and local mobilization (Hermans et al., 2017). These diverse coalitions with appropriate network actors can increase the likelihood of a successful scaling activity (Wigboldus & Leeuwis, 2013). In Ethiopia, de Roo et al. (2019) found that income disparity between farmers was exacerbated by

two malt barley interventions that required access to certain technology. Access to the technology was limited due to social levers that ultimately controlled access to a wide range of resources, such as clan-based loyalty, reciprocity, and vertical accountability.

When looking at a highly successful chickpea variety adoption in Ethiopia, Verkaart et al. (2019) found a favorable enabling environment encouraged adoption rates to rise from 30% to 80%. There was good market access, accessible extension services, and the chickpea was already an important crop and thus held value in the community. The authors concluded that the “conducive environment” enabled adoption and that ex-ante analysis of how scaling processes will impact a community is important. While these are important findings, their analysis would have been strengthened by including disaggregated data for men and women, since it is difficult to know if the intervention was as successful for women, or other marginalized populations. While market access and extension services were important factors in facilitating adoption, heterogeneous populations will experience the external environment differently, and thus the enabling environment will be different.

Anticipatory questions: Is there a policy or social norm that somehow excludes access to the innovation, complementary inputs, or systems necessary to exchange and interact with the intervention? Is there a social norm that promotes the exclusion of specific groups from political processes? How do institutions enable or constrain the scaling pathway? What partnerships are in place across multi-level stakeholders?

3.4. Section II: Strategies on how to collect data for anticipatory questions

The following methods were pulled from ex-ante and anticipatory literature as potential ways to collect data to better understand gendered consequences of scaling. Some methods are well established, such as focus group discussions, and others are more specific and targeted to certain information needs. They are all meant to be used in conjunction with and guided by the anticipatory questions.

Many of the above anticipatory questions focus on labor needs, so we have provided a method called “labor mapping” below to better understand the labor landscape in communities. Anticipatory questions also included questions concerning decision-making power, and thus the Women’s Empowerment in Agriculture Index is included. Due to the complicated nature of gathering data on income, time, resources, decision making, and other critical scaling factors, we have attempted to provide a short menu of data collection and analysis tools so that researchers, practitioners, and community members may consider using them if more information is needed to answer the anticipatory questions. However, other resources are available; the ones included here we found to be the most relevant and accessible methodologies.

Participatory Rural Appraisal (PRA): This research methodology is an extension of the “Rapid Rural Appraisal” that derives knowledge from the community itself instead of community outsiders. First introduced by Robert Chambers in the 1990s, it provides an umbrella for several methods to garner insight and uphold local knowledge – ultimately improving research integrity and development outcomes (Chambers, 1994). We have highlighted four data collection tools relevant to gender and scaling.

- **Labor mapping or “daily time use analysis”:** This concept highlights relative amounts of time used on specific activities, degrees of the drudgery of activities, and sometimes indicates seasonal variation. These data are usually collected during a workshop with a group of intended innovation users or individuals marking their daily activity over a certain amount of time.
- **Resource mapping or “resource-based view”:** Similar to labor mapping, resource mapping allows a community or focus population to highlight who has what resources, usually around a specific question or system. More recently, resource mapping has been used

in conjunction with *scenario thinking* to better understand the interaction of a focus group’s resources with the external environment under various scenarios (Kunc & O’Brien, 2017). Scenario thinking is described in further detail below. Resource mapping is generally done in focus groups or a workshop setting.

- **Participatory social mapping:** This method allows communities to map where social power and levers lay within a system. These data are collected through focus groups and workshops. Careful attention should be given to the composition of these groups, as data from social mapping can change significantly, depending on the group’s demographics.
- **Analysis of difference:** In this method, a practitioner identifies differences between groups, including their challenges and preferences, especially gender, social group, wealth/poverty, occupation, and age. This includes contrast comparisons - asking one group why another is different or does something different.
- *The Origins and Practice of Participatory Rural Appraisal* (Chambers, 1994) provides more in depth description of many of these tools.

Women’s Empowerment in Agriculture Index (WEAI): The WEAI is a collaboration between the International Food Policy Research Institute, Oxford Poverty and Human Development Initiative, and USAID Feed the Future, which launched in 2012 and is a continuously evolving set of indicators to measure women’s empowerment in the agriculture research for development setting. The WEAI seeks to “track gender equality and measure empowerment, agency, and women’s inclusion in the agricultural sector” through assessing five empowerment domains (IFPRI, 2019). Data are collected through survey methods, and a newer version of the WEAI has been modified for use in a project assessment (Pro-WEAI). Indicators include autonomy in income, self-efficacy, attitudes about domestic violence, input in productive decisions, ownership of land and other assets, access to and decisions on credit, control over the use of income, and work balance. The tool can be found here: <https://www.ifpri.org/project/weai>.

Genovate: GENNOVATE is a global initiative led by the Centers for International Agricultural Research (CGIAR) to compare how local cultural norms impact how women interact with agricultural innovations. While most of this research is done over longer periods of time by researchers who focus specifically on gender relations, they do provide accessible gender research tools available to anyone. These tools can help researchers, practitioners, and community members collect data on why women would or would not adopt innovation in a certain setting. One of these tools, *the Ladder of Life*, helps data collectors better understand how well-off groups of people are within the community, and the factors that contribute to this well-being. These can be found here: <https://genovate.org/gender-tools-for-scientists/>.

The Rural Household Multiple Indicator Survey (RHoMIS): RHoMIS is a standardized household survey that collects information on 758 variables organized into key indicator groups around decision making, on-farm activity, food, and poverty dynamics (van Wijk et al., 2020). These indicators are then used as inputs into standardized indices, such as the Probability of Poverty Index, Household Diversity Dietary Score, and the Potential Food Availability Indicator. The survey is administered through modules or indicator groups, of which particular interest is the “gendered control of produce and income.” In this module, questions are asked about produce and income per item, who makes decisions on sales, spending, and consumption. Since the survey is designed to be less than an hour, further exploration of decision-making nuances is not possible (the WEAI and GENNOVATE can expand upon). Another module of interest is the Household Dietary Diversity Index, which measures women’s eating habits in the worst, best, and last month. Additionally, household demographics collect the sex of the respondent and whether or not they are in a couple or single – so one could use other relevant data points and disaggregate along these lines. This tool helps assess a community scenario, and in a limited fashion, the women in that community, but further disaggregation is

needed to understand a focus population. This tool can be found here: <https://www.rhomis.org/>.

Scenario thinking: Scenario thinking is a structured process that allows a group to think about and anticipate future potential situations and their outcomes. A suite of potential situations are presented and groups of relevant stakeholders play out possible outcomes and reactions. Scenario thinking has historically been used within military planning but more recently applied within the financial community. However, it could potentially play a role in agricultural innovation and scaling systems, as well (Owen et al., 2013). In order to avoid technological determinism, scenario thinking may be best suited when other data has been collected through focus groups and other participatory methods. Wright & Cairns (2011) provide an overview of methodologies and applications of scenario thinking.

The theory of affordance might be well suited to guide scenario thinking within agricultural innovation and scaling systems. First put forward by James Gibson in 1979 it has now been adapted for use in broader ecological, economic, and development applications. The basic premise is that an environment provides affordances or an enabling environment for an entity, and as a result, it flourishes (Gibson, 1979). In this application, social, economic, environmental, and cultural variables that offer a perceived enabling environment for an innovation become relevant. Practitioners might apply the theory of affordance as a method to assess enabling environments in an ex-ante analysis of pathways to scale. Ditzler et al. (2018) provide an overview of the theory and the application of the theory of affordance in agriculture innovations.

The **expected-profits approach** was first put forward as a method of ex-ante analysis by Caswell et al. (1998) for use in California's biotech industry. The method uses historical data on prices and assumptions of future prices and policy conditions. This technique is relatively simple in concept. It uses farm-level financial and other data to determine which producers would find innovation adoption profitable and thus, probably adopt it. However, it is important to note that other non-financial and significant factors contributing to adoption are not exhibited in this model (Kuehne et al., 2017). If used with an *analysis of difference* approach, a comparison of profit between different sub-groups could provide helpful insight into the ultimate beneficiaries of new technology.

Further, one could consider a broad range of *distribution of benefits* within different sub-groups of users. The expected profits approach under an analysis of difference lens could yield interesting insight into profit differences. Still, other variables, such as social and institutional capital, human capacity, and labor savings could provide insight into who might benefit. Data collection on different variables could occur through PRA methods. The *historical-trends approach* uses survey data or other existing literature of past adoption behavior to predict farmers' adoption of a new practice (Caswell, Fuglie & Klotz, 1998). This can help assess similar types of innovations' path to scale – particularly unforeseen challenges or beneficiary discrepancies.

Focus groups deserve special attention as a data collection method because they allow the researcher or practitioner to gather information in the most non-prescriptive way. This will enable issues that the ex-ante analysts do not foresee to percolate from the community most likely to be impacted (or not) by the intervention. Macnaghten (2017) describes an 'upstream' focus group anticipatory methodology that considers new technology's context, framing, moderation, sampling, and analysis and interpretation. These methods help draw out the imagination and concerns of marginalized groups without undue 'expert' guidance and therefore prescription or projection. Rodriguez et al. (2011) explain the methods and application of a 'culturally responsive focus group.'

3.5. Section IV: Perspective: Implications for development programs and introduction to a gender responsible scaling methodology

This review analysis generated six points of unique gender

considerations: i) Comprising research and project teams, ii) Designing agricultural innovations, iii) Communicating and extension of innovation, iv) Choosing scale models: entrepreneurship and business development, v) Reinventing and changing technology, and vi) Political economy of innovation. Reflecting on these unique gender considerations, academic and project teams are encouraged to think through the provided reflection questions. Finally, are provided. These included PRA methods, WEAI, GENNOVATE, RHoMIS, scenario thinking, theory of affordance, expected-profits approach, historical-trends approach, and focus groups.

Recently, there has been a wave of interest in gendered impacts on experiments and interventions across the sciences. From the medical sciences to glaciology, the *scientific* approach to study design, starting from theory through experimentation and interpretations of results, is being questioned as patriarchal and gender-blind (Carey et al., 2016; Nielsen et al., 2017). This literature review reveals that more effort must be placed on understanding how innovation for development might impact focus groups, with particular attention to gender. Researchers and practitioners can often identify relevant diversities such as ethnicity, wealth, and region but fail to respond appropriately to the intersection of gender within each of these categories.

We hope this work moves beyond previous calls to action for disaggregating data, as it provides a number of methodological approaches for program-level gender-equitable development interventions (Klasen et al., 2016). Here, we also include references to qualitative research approaches, often more gender-inclusive (Jaggar, 2008). Validation of and increased use of various methods suitable for researchers and project managers could lead to better informed scaling strategies. More information on collecting required data from available sources and bringing those data together with the appropriate experience and expertise is needed. Agricultural innovation and scaling systems should consider more holistic approaches to gender responsible scaling, and tools that embody this are needed. Considering insights from the literature, scaling support tools and methodologies should incorporate a series of gender and intersectionality sensitizations and scaling discussion questions to promote more informed scaling processes.

CRediT authorship contribution statement

Erin McGuire: Writing – original draft, Formal analysis. **Anne M. Rietveld:** Writing – review & editing, Funding acquisition, Project administration, Supervision. **Amanda Crump:** Writing – review & editing, Supervision. **Cees Leeuwis:** Writing – review & editing, Funding acquisition, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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