GENDER Impact Platform

CGIAR

Review of impact assessments on women's economic empowerment and technology adoption

CGIAR GENDER Impact Platform

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ABOUT CGIAR GENDER IMPACT PLATFORM

Generating Evidence and New Directions for Equitable Results (GENDER) is CGIAR's impact platform designed to put equality and inclusion at the forefront of global agricultural research for development. The Platform is transforming the way gender research is done, both within and beyond CGIAR, to kick-start a process of genuine change toward greater gender equality and better lives for smallholder farmers everywhere. gender.cgiar.org

DISCLAIMER

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1. Introduction

This report reviews impact assessments undertaken across the CGIAR portfolio. Impact assessments at CGIAR provide empirical evidence to help policymakers, researchers and stakeholders make informed decisions about which agricultural technologies and practices to promote, scale or invest in. These assessments can focus on short-, medium- and long-term outcomes.

This report synthesizes the current body of evidence on CGIAR impact assessments focused on gender published in the CGSpace database, highlighting key insights and takeaways from these studies, focusing particularly on assessments on women's economic empowerment and women's adoption of agricultural technologies. The report also examines the strengths and weaknesses of the methodologies used and identifies research gaps and areas where further evidence is needed. The aim of this report is to guide future CGIAR gender research to inform solutions to close gender gaps and empower women in agri-food systems.

2. Methodology

For the purpose of this review, impact assessments were defined as objective assessments of a program's outcomes and impacts, designed to study the causes of and contributions to change by an initiative or intervention, including the use of quantitative, qualitative or mixed methods to measure changes in outcome and impact indicators. The review focuses on assessments on (1) women's economic empowerment and (2) women's adoption of agricultural technologies. Between October and November 2024, keyword searches were conducted on the CGSpace portal. The keyword search terms "gender" AND "empowerment", "gender" AND "technology adoption" were used and the search was limited to three types of publications published between 2010 and 2024: journal articles, reports and working papers. The search encompassed all geographical regions, countries and CGIAR centers.

The keyword search for women's economic empowerment, visually summarized in Figure 1, yielded 465 journal articles, 931 reports and 494 working papers. Title and abstract screening of these documents identified 80 relevant studies.

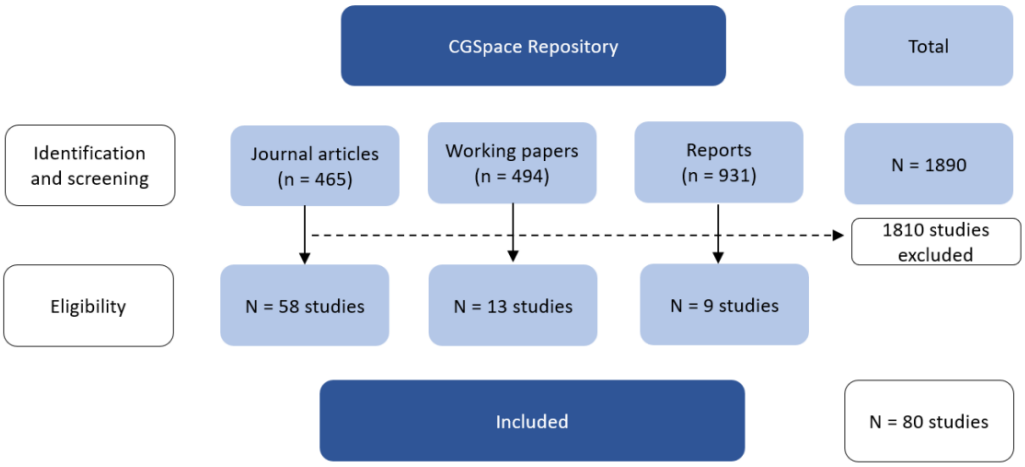

Figure 1: PRISMA chart for impact assessments on women's economic empowerment

The search for women's agricultural technology adoption, visually summarized in Figure 2, yielded 272 journal articles, 308 reports, 389 working papers and one book chapter. Title and abstract screening of these results identified 44 relevant studies. Thus, the results for technology adoption studies were considerably fewer than those for women's economic empowerment studies.

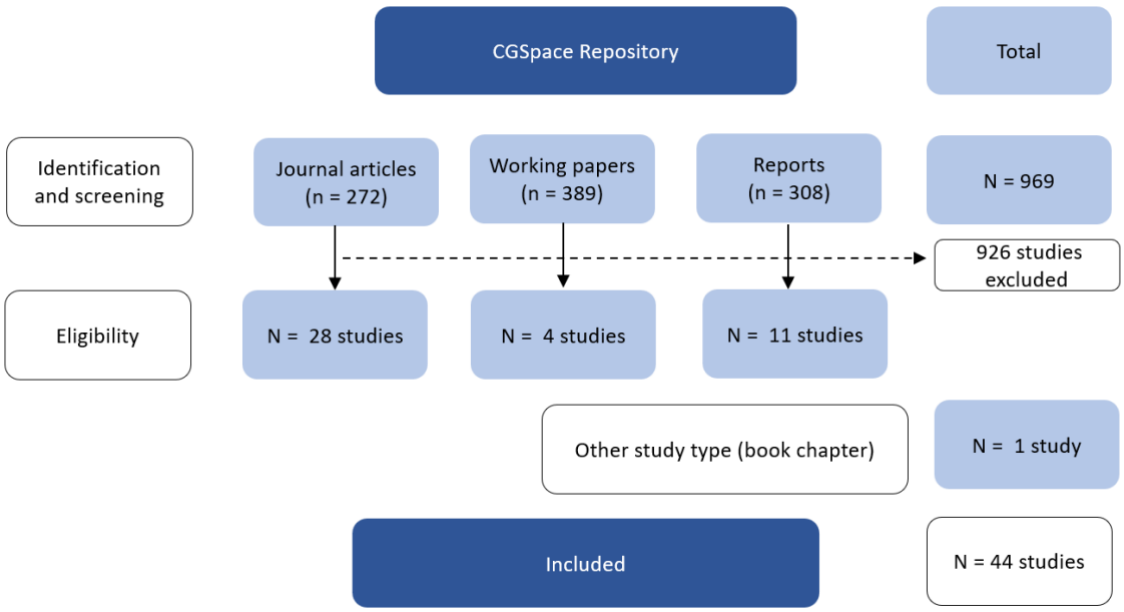

Figure 2: PRISMA chart for impact assessments on women's technology adoption

The methods used in the studies included in the review were:

1. experimental studies (e.g., randomized controlled trials)
2. quasi-experimental studies (e.g., difference-in-differences, matching methods, regression discontinuity design, instrumental variables and fixed effects)
3. non-causal impact assessments (e.g., before/after assessments)
4. qualitative-only studies

With the exception of the qualitative-only studies, all other methods may have also included a qualitative component, making them mixed-methods studies.

Interventions were classified into eight categories for studies on women's economic empowerment. Studies may belong to more than one category as an intervention may have multiple components. Table 1 lists the intervention categories and examples of the interventions. The interventions with most studies are related to training (40 studies) and asset transfers (24 studies).

Table 1. Categorization of interventions on women's economic empowerment

Category	Short description
Asset transfers	Provision of inputs (tools, seeds, poultry etc.)
Cash transfers	Unconditional and conditional transfers, pensions
Commercialization	Agricultural commercialization for seeds, vegetables
Finance	Savings and credit groups, microfinance interventions, self-help groups
Information/knowledge dissemination	Radio programming, video extension, agricultural extension, interactive storytelling, social audit (beneficiary-led monitoring and evaluation)[1]

[1] The social audit process is designed to sensitize communities to their rights and entitlements under government schemes. For example, in the Collective Action for Nutrition Social Audit in Odisha, the seven-day process in each Gram Panchayat includes village meetings, focus

Category	Short description
Training	Nutrition behavior change communication, homestead food production, WASH, gender sensitization, enterprise development, agricultural training programs
Group membership	Dairy cooperatives, farmer producer organizations, collective action models
Regulatory framework	Forest rights, climate mitigation

Interventions were classified into eight categories for studies on women's technology adoption. Table 2 lists of categories and examples of the interventions. The interventions with most studies are those related to training (20 studies), information/knowledge dissemination (10 studies) and technological innovations (10 studies).

Table 2. Categorization of interventions on women's technology adoption

Category	Short description
Asset transfers	Provision of inputs (tools, pumps, seeds, poultry etc.)
Commercialization	Agricultural commercialization for seeds, dairy, roots, tubers, beans
Finance	Seed credit models, microcredit, subsidies and loans
Technological innovations	Improved livestock, roots, tubers, bananas, seeds, farm inputs and equipment
Information/knowledge dissemination	Radio programming, video extension, agricultural extension, demonstrations, climate forecasts and agro-advisories
Training	Agricultural (improved seed, technology, equipment-related) and livestock-related training programs, gender sensitization, nutrition training
Group membership	Dairy cooperatives, community seed banks, collective action models, public–private partnerships

group discussions with local council members, field surveys, data collection from the National Food Security Act rights holders, and verification of registers. This process is followed by data compilation and report writing. The intervention concludes with a public hearing, held as a formal Gram Sabha, to share findings and grievances. In the post-social audit phase, the social audit team follows up on National Food Security Act grievances with relevant government officials.

3. Results: Women's economic empowerment

3.1 Where the evidence came from

3.1.1 CGIAR center coverage

Figure 3 shows which CGIAR center the impact assessments included in this review were derived from.

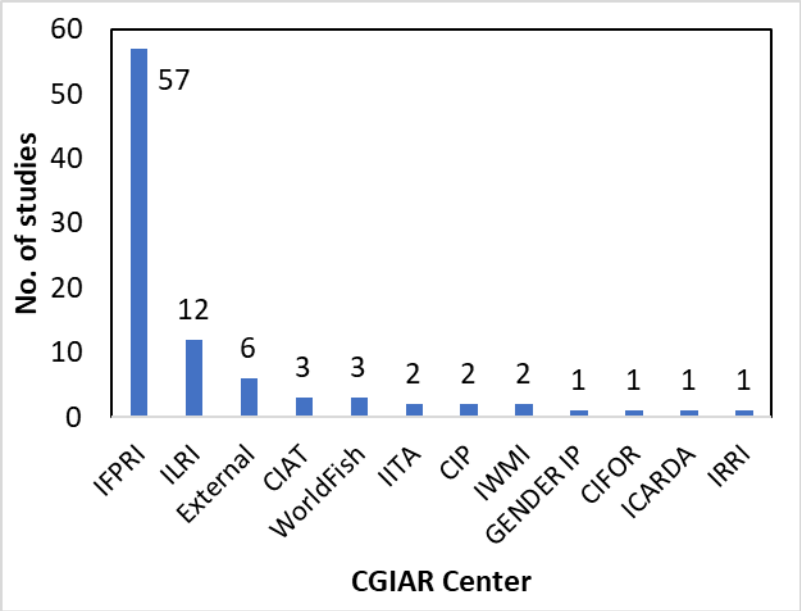

Figure 3: Studies by CGIAR center
Note: The total count exceeds 80 as some studies have authors affiliated with multiple CGIAR centers

Of the 80 included studies on women's economic empowerment, 50 are solely affiliated with the International Food Policy Research Institute (IFPRI). Seven studies are collaborations between IFPRI and other CGIAR centers including International Livestock Research Institute (ILRI), International Water Management Institute (IWMI), International Institute of Tropical Agriculture (IITA) and Landesa (external). Seven studies are solely affiliated with ILRI, while five are collaborations between ILRI and other centers.

Six studies are from external partner institutions. These institutions include Oxford University, Food and Agriculture Organization (FAO), the United National development Programme (UNDP), African Women in Agricultural Research and Development (AWARD), Wageningen University, Emory University, Potsdam Institute for Climate Impact Research and Montana State University.

Three studies are from the International Center for Tropical Agriculture (CIAT); one study is solely affiliated with Worldfish; and two studies are collaborations between Worldfish and IITA and Worldfish and the International Potato Center.

Only one study is affiliated with the Center for International Forestry Research (CIFOR), the International Center for Agricultural Research in the Dry Areas (ICARDA) and the International Rice Research Institute (IRRI). One study is a collaboration between the CGIAR GENDER Impact Platform and IFPRI.

3.1.2 Geographical coverage

Figure 4 shows the countries the impact assessments included in this review were derived from.

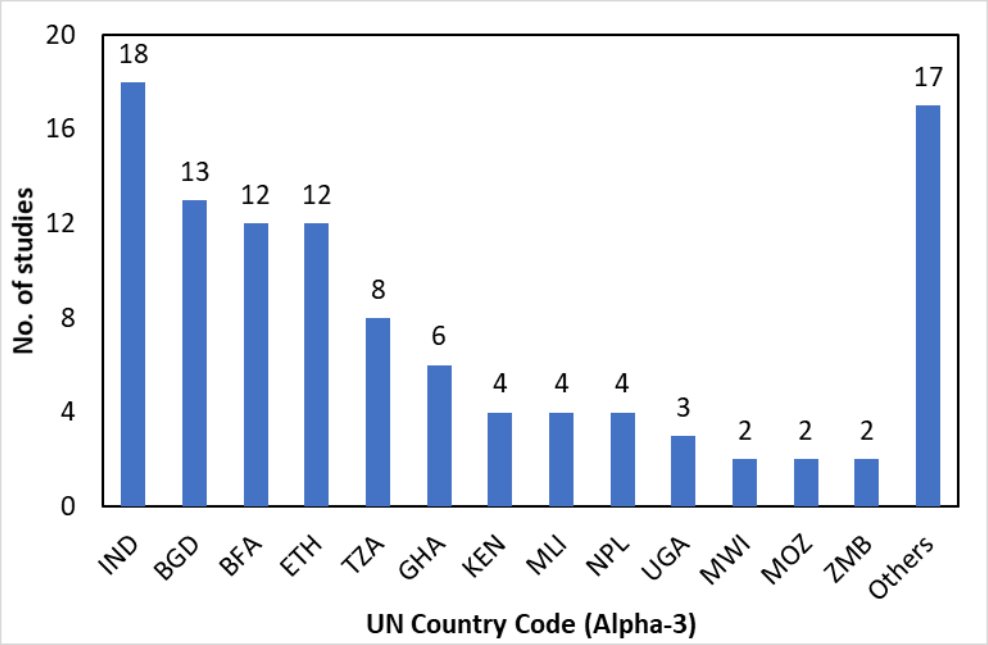

Figure 4: Studies by country
Note: The total count exceeds 80 as some studies cover multiple countries.

A majority of studies focus on South Asia and Sub-Saharan Africa. India was the most represented country (18 studies), followed by Bangladesh (13 studies), and Burkina Faso (12 studies) and Ethiopia (12 studies). Other countries from South Asia represented included Nepal (4 studies), Myanmar (1 study) and Pakistan (1 study). There were no studies from Afghanistan, Sri Lanka, Bhutan or the Maldives.

In Sub-Saharan Africa, 12 studies were from Ethiopia, eight studies from Tanzania, six from Ghana, four from Kenya, four from Mali and three studies were from Uganda. Mozambique, Malawi and Zambia had two studies each.

Seventeen countries were represented by one study each (Others category). In Sub-Saharan Africa, these countries included Benin, Cameroon, Djibouti, Nigeria, Niger, Rwanda and South Africa. In the Middle East and Africa (MENA) region, Egypt and Syria were represented by one study each. In Latin America, there was one study in Brazil and Peru. In East Asia, Indonesia, Lao PDR and Viet Nam were represented by one study each. Kyrgyzstan had one study and was the only country from Central Asia.

3.2 Methodological approaches used

3.2.1 Overview

The methods breakdown for the impact assessments on women's economic empowerment was:

- *Experimental:* 32 studies (10 mixed methods, i.e., included a qualitative component). A majority of these studies were cluster-randomized controlled trials, where randomization was conducted at the community, village or block level. The majority of impact assessments on women's economic empowerment were experimental (32 studies) and quasi-experimental (19 studies). Most of the experimental studies were cluster randomized control trials.
- *Quasi-experimental:* 19 studies (8 mixed methods). Across studies using quasi-experimental methods, nine studies used difference-in-differences, 10 used a form of matching (propensity-score, nearest-neighbor, inverse-probability weighting, entropy balancing), three used a regression-discontinuity design and only one used fixed-effects estimation. Of the nine difference-in-differences studies, five used a matched difference-in-differences estimation. One study was a synthesis review, including experimental and quasi-experimental methods.
- *Non-causal assessments:* 10 (7 mixed methods). These studies used baseline and endline quantitative survey data to document changes in the context of the program or intervention (assessing

contribution rather than attribution). Seven studies in this category were accompanied by qualitative data collection (focus group discussions and interviews).

- *Qualitative only*: 19 studies. Focus group discussions were the most commonly used qualitative tool. Additionally, many studies used key informant interviews. Qualitative data collection in most of these studies took place within a short timeframe. Only one study used exploratory small-n research. In this study, 12 women respondents from 10 households were interviewed weekly for a period of four to six months each year over five years (2006–2011).
- Overall, 25 of 80 studies on WEE classified as mixed methods.

3.2.2 Mismatch in methodological approaches and validation shortcomings

Three studies that reported being quasi-experimental lacked a true quasi-experimental design. Instead, these studies were coded as non-causal assessments, as they primarily measured changes in outcomes over time (without a counterfactual).

Cole et al. (2020) compared two approaches addressing gender constraints within a broader post-harvest fish loss reduction intervention in Zambia: a gender accommodative and a gender transformative approach. The study used the Women's Empowerment in Fisheries Index (WEFI) at baseline (2015–2016) to 148 participants (58 women, 90 men) before gender-related activities began. The endline survey was conducted in December 2016 with the same group presenting baseline and endline outcomes without applying causal inference methods.

Larson et al. (2018) examined the change in women's wellbeing status in response to a Reducing Emissions from Deforestation and Degradation (REDD+) initiative in six countries. Although the study mentions that it presents a difference-in-differences analysis, this is not the case. Rather, the paper conducts a regression analysis with lagged independent variable.

Waweru et al. (2021) examined the impact of a participatory rangeland management project in Kenya and Tanzania on women's participation in rangelands management. The study adopts a mixed-methods approach and is described as a quasi-experimental design. However, it does not clarify which specific quasi-experimental method was used or how it was validated. The study only notes that treatment and control sites were selected to have similar geographical and socioeconomic conditions. Causal inference methods were not applied.

In addition to methods mismatches, we also noted a number of validation shortcomings.

Breisinger et al. (2018) use a regression discontinuity design approach to assess the impacts of two cash transfer programs in Egypt, Takaful and Karama. The regression discontinuity design approach for estimating Karama's program impacts faced challenges due to a small sample size, the program's inclusion threshold shifted between sample selection and data collection, and rapid enrolment of the comparison group into the program. This caused significant issues with the study's internal validity, as the control group was compromised and could not be used. Therefore, it was not possible to assess the impact of the Karama program.

Kumar et al. (2024) examined the impact of an integrated agriculture-nutrition intervention on women's empowerment and nutrition outcomes in India. Although the study used a matched difference-in-differences analysis, the lack of data to test the parallel trends assumption precludes a causal interpretation.

3.2.3 How the WEAI tool was used in the impact assessments

Thirty studies on women's economic empowerment used a version of the Women's Empowerment in Agriculture Index (WEAI) tool to measure empowerment. Of these studies, 18 used the pro-WEAI, six used the A-WEAI and four used the WEAI. One study (Cole et al. 2020) used the Women's Empowerment in Fisheries Index (WEFI). Two studies (Njiru et al. 2024 and (Mwambi et al. 2021) used the Women's Empowerment

Livestock Index (WELI). One study (Farnworth et al. 2024)) used the Women's Empowerment in Livestock Business Index (WELBI).[2]

The 18 studies that used the pro-WEAI measured the following indicators:

- The individual empowerment score, defined as the weighted sum of the 12 pro-WEAI indicators; this score ranges from 0 to 1.
- The individual's empowerment status, which classifies an individual as empowered if their empowerment score is greater than or equal to 75% of the weighted sum of the 12 binary pro-WEAI indicators.
- Component indicators of the pro-WEIA including indicators of intrinsic agency (autonomy in income, self-efficacy, attitudes about intimate partner violence against women, respect among household members), instrumental agency (input in productive decisions, ownership of land and other assets, access to and decisions on credit, control over use of income, work balance, visiting important locations) and collective agency (group membership and membership in influential groups) (Malapit et al. 2019)).
- Gender parity: A household achieves gender parity if the woman is empowered (based on the definition in the first dot point) or if she achieves at least the same empowerment score as her partner; thus, gender parity is a binary indicator at the household level.
- Gender attitudes composite score: Based on men's and women's degree of agreement with statements related to attitudes, a higher score is associated with more gender-equitable attitudes.

The six studies that use the A-WEAI measured the following empowerment indicators:

- Whether the individual is empowered, defined as achieving at least an empowerment score of 80% (binary indicator) on six indicators. These indicators are 1) input in livelihood decisions; 2) ownership of land and other assets; 3) access to and decisions on financial services; 4) control over use of income; 5) work balance; and 6) group membership.
- The individual empowerment score, the weighted proportion of indicators in which a response is adequate (continuous indicator).
- Whether the household achieves gender parity (the woman's empowerment score is greater than or equal to the empowerment score of the male decision-maker in her household (binary indicator)).
- Since binary indicators may be sensitive to the choice of thresholds, some papers also analyze the underlying continuous variables to determine adequacy.

Four studies used outcome measures based on the original WEAI methodology. This includes the individual-level five key domains of empowerment (5DE) scores, the gender gap in empowerment, and several of the component questions:

- The WEAI identifies five key domains of empowerment (5DE): (1) decision-making power in agricultural production; (2) access to and decision-making power over productive resources; (3) control over income use; (4) leadership in the community; and (5) time allocation (Alkire et al. 2013). Each domain is made up of one to three sub-indicators, and a respondent is considered empowered in a given sub-indicator if they meet predetermined thresholds or cutoffs. A simple, nested weighting system, where each domain is assigned equal weight, is used to calculate a composite score known as the 5DE score. This score reflects the level of empowerment an individual has, with a higher score indicating greater empowerment. By comparing the 5DE scores of husbands and wives within the same household, the gender gap in empowerment can be assessed. In households where the woman is fully empowered, the gender gap is zero. In households where the woman is not empowered, the gender gap measures the difference in empowerment between the man and woman, highlighting the degree to which women's empowerment

[2] The Women's Empowerment in Agriculture Index (WEAI) is a standardized tool designed to measure women's empowerment and gender parity in agriculture. It includes the original WEAI, the streamlined Abbreviated WEAI (A-WEAI), and project-specific versions such as Pro-WEAI. The tool has also been adapted for use in the fisheries and livestock sectors.

needs to be increased to reach parity with men. A larger gender gap indicates a greater shortfall in women's empowerment.

Cole et al. (2020)used WEFI outcomes examined include gender equal attitude scores; levels of women's involvement in fishing and processing and trading fish, and women's input into household decisions about the income generated from fishing and processing and trading fish.

Mwambi et al. (2021) and Njiru et al. (2024) used the WELI and the following indicators:

- decisions about agricultural production (in the past year)
- nutrition decisions (milk-related)
- access to and control over land and non-land resources
- access to credit
- control and use of income
- access to and control over opportunities: who mostly accessed agricultural extension services in the past year and who made most decisions on where to sell milk in the past year
- total workload (time use)

3.2.4 Other ways to measure women's empowerment

Njiru et al. (2024) measure changes in empowerment (remaining/becoming disempowered vs remaining/becoming empowered) on basis of:

- WELI empowerment score
- autonomy in income
- respect among household members
- input in productive decisions – livestock
- ownership of land and other assets
- control over use of income

Farnworth et al.(2024) used the WELBI to measure the following indicators:

- intrinsic agency: autonomy in income, self-efficacy, attitudes toward domestic violence and respect among household members
- instrumental agency: input in productive decisions, ownership of land and other assets, access to and decisions on credit, control over use of income, work balance and visiting important locations
- collective agency: group membership and membership in influential groups

3.2.5 Other outcomes analyzed

Fifty studies measured empowerment, but did not include a WEAI tool. Commonly included outcomes in these studies were women's household and farm-related decision-making, control over income, gender norms, women's land and non-land asset ownership, access and control over productive resources, participation in community savings and lending groups such as self-help groups , social networks mobility and confidence in public spaces.

Outcomes not covered in the WEAI tools and captured by only a few studies include:

- Kumar et al. (2019) and Gordon et al. (2019) examined outcomes such as women's political participation, awareness and use of government entitlements and use of confidence to take up grievance redressal processes.
- Bose (2011) specifically examined tribal women's access to forestland, forest resources, and inclusion in collective decision-making about forestland management and Waweru et al. (2021) considered women's participation in rangelands management.
- Sessou et al. (2022) considered impacts on girls' schooling outcomes, grade completion and enrolment, as well as time use.
- Leight et al. (2024) captured variables linked to aspirations and forward-looking behavior such as investment in education and savings.
- Larson et al. (2018) measured women's perceived well-being in response to REDD+ climate mitigation initiatives.

Several studies also examined program impacts on women and children's dietary and nutrition outcomes (e.g., household, women and children's dietary diversity and quality scores, calorie intake, egg consumption, mother's body-mass index (BMI), and children's underweight, stunting and wasting). These studies used women's empowerment indicators as a pathway (mediators) for the final nutrition-related outcomes.

Five studies that did not use the pro-WEAI still measured either attitudes towards intimate partner violence or the prevalence of physical, sexual and emotional intimate partner violence, in conjunction with other women's empowerment outcomes.

3.3 Key findings and trends

3.3.1 Expanding access to resources alone is not sufficient for women's economic empowerment

The reviewed studies suggest that asset transfer programs often fail to significantly enhance women's decision-making power or agency. For instance, Bryan and Mekonnen (2023) found that expanding access to small-scale irrigation technologies increased household income and food security; however, the intervention did not expand women's decision-making influence in key spheres of life. Similarly, an Enhanced Homestead Food Production program that targeted women with agricultural inputs and training did not result in significant post-program effects on women's empowerment (Bliznashka et al. 2022). The Challenging the Frontiers of Poverty Reduction — Targeting the Ultra Poor program, which provided livestock to women, resulted in increased asset ownership, but new investments made with mobilized resources were largely controlled by men. Additionally, women experienced reduced mobility and control over their income, as the livestock required home-based maintenance, reinforcing gendered divisions of labor and power (Das et al. 2013; Roy et al. 2015). Johnson et al. (2015) showed that in a gender-blind intervention that distributed dairy cows, women had limited control over the income generated from milk, which was often controlled by men. This underlines the fact that ownership of resources does not automatically translate into control over the benefits derived from those resources.

Results from qualitative studies also suggest the lack of impact on women's empowerment through asset transfers. An intervention that transferred a motor pump for small-scale irrigation had limited benefits for women, as they could only access land for irrigated cultivation through their husbands and, therefore, had less control over the decision of whether to produce irrigated crops (Bryan & Garner 2022). Shrestha et al. (2023) highlighted that gender and social inequalities continue to limit the adoption and benefits of solar irrigation pumps among women and smallholders. Women's involvement in key decisions related to the adoption, installation and use of solar irrigation pump technology is minimal. The PRADAN's Livelihoods Enhancement through market Access and Women Empowerment project, which provides farmer producer organizations for smallholder women farmers with agricultural and gender-based inputs showed to improve women's decision-making, asset ownership, and income control, but increased workloads for both genders and men appeared to cede control over resources and decision making to other household members (Bhanjdeo 2024).

The impact of asset transfers on intrahousehold dynamics is mixed, potentially leading to backlash effects. The livestock transfer provided as part of the Strengthen Productive Safety Net Programme in Ethiopia did not lead to sustained improvements in intrahousehold dynamics or women's empowerment. Impacts that appeared at midline, in part due to the livelihood transfers (i.e., poultry transfer), dissipated by endline (two years after the distribution of the livelihood transfer) (Alderman et al. 2021). A seed credit model that enhanced access and availability of improved seed quality for women and men farmers had positive impacts on productivity, income and enhanced food and nutrition security for families. The intervention shifted power dynamics, empowering women within households (increased income and decision-making over income from the sale of their crops). However, to maintain control, some men restricted women's access to fertile land and family labor, directly influencing the quantity of seed obtained through the seed credit model. This shift also exacerbated domestic violence, as some men perceived women's economic empowerment as a threat (Nanyonjo & Nchanji 2023).

Together, these studies suggest that while access to resources like land, livestock or irrigation can provide women with material benefits, it does not automatically lead to greater agency or empowerment. True

empowerment requires a more comprehensive approach that includes changing power dynamics, improving women's decision-making influence, and ensuring they have control over the resources and income they generate.

The Homestead Food Production program stands as an exception in efforts to empower women through resource transfers. Women with the most productive gardens and greatest improvements in agency attributed their success not only to their husbands' support but also to the encouragement of other women (Dupuis et al. 2022; Waid et al. 2022). Women in the intervention group exhibited agency levels comparable to men and significantly higher than those in the control group. In treatment villages, women reported greater control over their gardens, the products they produced, and the income generated, though men still held control over higher-value animals. While the broader impacts of these changes in women's decision-making power remain unclear, they may positively influence key outcomes such as food security, child nutrition, education, and women's overall well-being (van den Bold et al. 2015).

Santos et al. (2014) highlighted tenure security as an important factor for women's economic empowerment. A land allocation and registration program in India emphasized allocating land jointly and including women's names on the titles. Women listed on land titles reported significant improvements in tenure security and were more likely to actively participate in family decisions, outcomes that are expected to improve household and intrahousehold food security.

3.3.2 Training programs may be effective to increase women's agency, but further research is required on modality and context

Six studies examined the effect of the Soutenir l'Exploitation Familiale pour Lancer l'Élevage des Volailles et Valoriser l'Économie Rurale (SELEVER) poultry intervention in Burkina Faso. The program aimed at increasing poultry production and improving the diets and nutritional status of women and children through nutrition-related trainings, while it specifically excluded any asset transfers. Results from experimental studies show that the intervention had no impact on empowerment or gender parity, despite its gender-sensitive design (Heckert et al. 2023; Leight et al. 2022). However, qualitative research revealed greater community awareness of women's time burdens and economic roles, more women being involved in poultry rearing and income-generating activities, and importantly, more husbands being supportive of these activities (Eissler et al. 2020a, 2020b).

Interventions that combined agricultural training and nutrition behavior change communication appeared to have positive effects on women's economic empowerment (Quisumbing et al. 2021; Ahmed et al. 2023; Hoddinott et al. 2023). However, nutrition behavior change communication delivered through self-help groups was not associated with improvements in women's decision-making and gender attitudes (Scott et al. 2022). Also, training on group functioning, financial literacy and agriculture and livelihoods through self-help groups had no impact on women's empowerment (Hoffman et al. 2021).

Homestead food production programs appear to positively affect women's empowerment, likely reflective of program activities centered on beneficiaries working together at the village model farms, participating in meetings related to the nutrition and health behavior change communication activities, and being more likely to meet with other women to discuss the new agriculture, health, and nutrition practices (Heckert et al. 2019; Olney et al. 2016; Bliznashka et al. 2022; van den Bold et al. 2015). Gender household approaches, which promote intrahousehold cooperation, seemed to have a positive effect on spousal cooperation, and women's control over farm decisions and income (Lecoutere & Chu 2022; Lecoutere & Campenhout 2022).

3.3.3 Cash transfers coupled with behavioral change interventions may be an effective combination to improve women's economic empowerment

Two studies suggested that cash transfers, when coupled with behavior change communication, could form an effective strategy for enhancing women's economic empowerment. Roy et al. (2024) find that in Bangladesh's Transfer Modality Research Initiative program, Cash+ behavior change communication improved women's economic resources, women's agency, women's social and community support, household poverty, and men's

emotional well-being. The addition of behavior change communication to either modality (cash or food) in the Transfer Modality Research Initiative program led to larger impacts on both consumption and assets (Ahmed et al. 2024). Behavior change communication may enhance greater income generation due to a group-based intensive format that fosters social capital among the women participating and their household members, as well as improving agency and self-confidence, knowledge and input into household decisions.

Ambler and de Brauw (2024) found stronger short-term effects of an unconditional cash transfer in Pakistan via the BISP Cash Transfer Program on women's empowerment, which suggests that the effects of cash transfers may eventually dissipate in the absence of other interventions. Ambler (2016) shows that the South African pension program has a large and statistically significant impact on the decision-making power of women who are eligible to participate.

Quantitative and qualitative methods complement each other in revealing diverse patterns and insights related to the impacts on women's economic empowerment. For example, in an evaluation of the Takaful cash transfer for poor households in Egypt (Breisinger et al. 2018), the quantitative impact evaluation showed a negative impact of Takaful transfers on an index of women's control over decision-making. During qualitative interviews, some women initially provided normatively prescribed responses, stating that men were the decision-makers when giving brief answers. However, their detailed narratives revealed otherwise. The study found that Takaful transfers had empowered some women to independently make spending decisions with the funds received.

3.3.4 Savings and credit groups are a promising route to women's economic empowerment, conditional on implementation

Studies in this review suggest that self-help groups' membership is associated with increases in women's livestock ownership (Raghunathan et al. 2023) and WEAI-based aggregate measures of women's economic empowerment (Kumar et al. 2021). Kumar et al. (2019) found that self-help group members are more politically engaged, more aware of and likely to avail themselves of public entitlements, have wider social networks, and have greater mobility. Raghunathan et al. (2019) found that membership of the Professional Assistance for Development Action (PRADAN) self-help group improved women's decision-making power around agriculture and decreased the gender gap in empowerment within the household.

The assessment of an intervention in Ethiopia that strengthened the technical capacity of women-run rural savings and credit cooperatives (RUSACCOs) is associated with higher women's economic empowerment and a reduced gap in empowerment between men and women (Quisumbing et al. 2023; Mulema 2018). Palash et al. (2024) found that community savings groups for fisherwomen in Bangladesh had positive impacts on women's savings, earnings from catching fish, alternative income-generating activities, and empowerment.

The assessment of the Jeevika self-help group program in India highlighted contrasting effects between small-scale implementation and rapid scale-up. While the first phase of the program positively impacted women's empowerment, the second phase (Hoffman et al. 2021) found no empowerment gains two years after the start of the program, despite increased self-help group membership, borrowing, and reduced reliance on informal credit. The second phase prioritized material benefits, such as loan access, rather than collective problem-solving. These findings emphasized the potential of large-scale self-help group interventions, while underscoring the need for a thoughtful and well-paced roll-out.

Two other studies (Bryan & Mekonnen 2023; Shrestha et al. 2023) found that providing women with access to credit to expand to the use of irrigation technologies does not improve women's economic empowerment, especially in patriarchal contexts where the intervention does not include activities aimed at transforming the norms that shape gender inequalities.

There were few impact assessments for interventions related to agricultural commercialization, information and knowledge dissemination, group membership (excluding credit-related groups), and regulatory frameworks for women's economic empowerment outcomes; therefore, we do not draw patterns from these interventions related to women's economic empowerment.

4. Results: Women's technology adoption

4.1 Where the evidence came from

4.1.1 CGIAR center coverage

Figure 5 shows which CGIAR center the impact assessments included in this review were derived from.

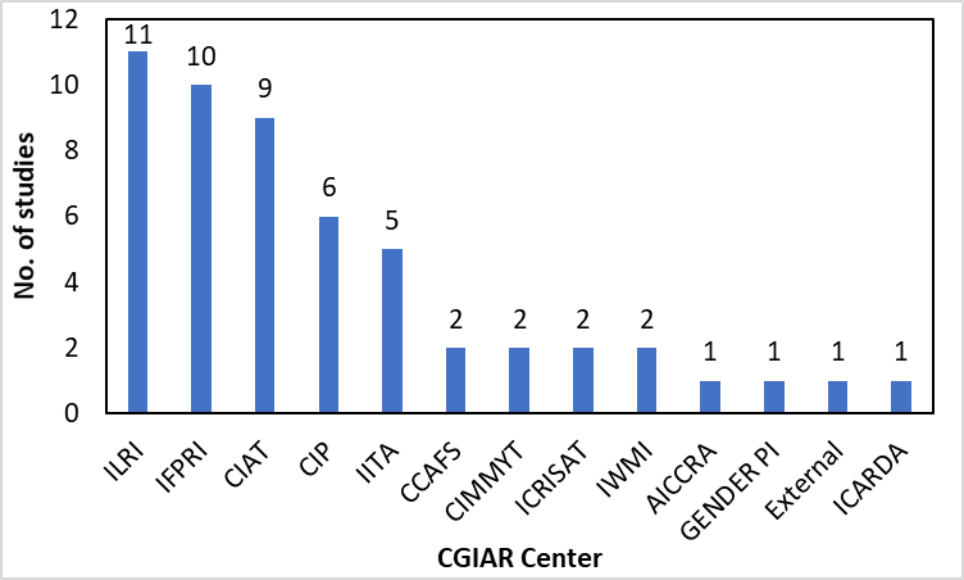

Figure 5: Studies by CGIAR center

Of the 44 studies on women's adoption of agricultural technologies, eight were solely affiliated with the ILRI, while three were ILRI collaborations with other centers including International Potato Center (CIP), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), ICARDA and IFPRI. Seven studies were solely affiliated with IFPRI, while three studies were collaborations between IFPRI and other CGIAR centers, including IWMI, CIAT, ILRI and the CGIAR GENDER Impact Platform.

Seven studies were solely affiliated with CIAT, while two studies are collaborations with other centers including International Maize and Wheat Improvement Center (CIMMYT), IFPRI and IWMI. Five studies were solely affiliated with CIP, while one is a collaboration with ILRI and ICRISAT. Four studies are solely affiliated with IITA, while one is a collaboration with CIMMYT.

Two studies are affiliated with the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Of the two studies each affiliated with ICRISAT and IWMI, one study has a sole affiliation with each institute, while the other is a collaboration.

One study is affiliated with Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA). One study is from Western University, an external partner institution. One study is a collaboration between the CGIAR Gender Impact Platform and IFPRI. One paper is a collaboration between ICARDA and ILRI.

4.1.2 Geographical coverage

Figure 6 shows the countries the impact assessments included in this review were derived from.

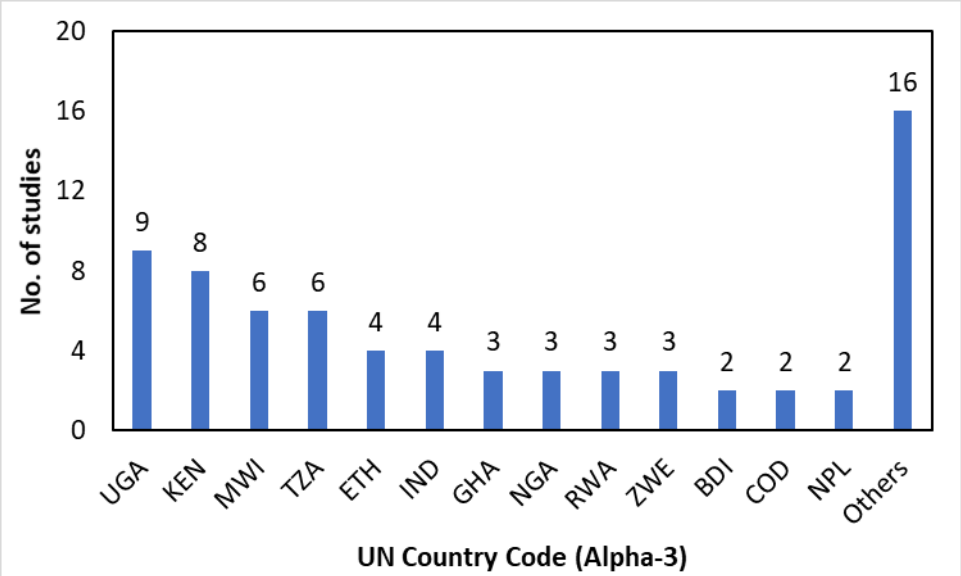

Figure 6: Studies by country

A majority of the studies focused on South Asia and Sub-Saharan Africa. Uganda was the most represented country (9 studies), followed by Kenya (8 studies), Malawi (6 studies) and Tanzania (6 studies). Countries from South Asia that were represented included India (4 studies), Nepal (2 studies), Afghanistan (1 study), Bangladesh (1 study) and Pakistan (1 study). There were no studies from Myanmar, Sri Lanka, Bhutan or the Maldives.

In other countries in Sub-Saharan Africa, four studies were from Ethiopia, three studies were from Ghana, Nigeria, Rwanda and Zimbabwe. Two studies were from Burundi and Democratic Republic of the Congo.

Sixteen countries were represented by one study each (Others category). In Sub-Saharan Africa, this included Benin, Burkina Faso, Gambia, Mozambique, Senegal, Sierra Leone, South Africa and Zambia. In the MENA region, Morocco and Tunisia were represented by one study each. In Latin America, there was one study each in Mexico and Colombia. Uzbekistan, with one study, was the only country from Central Asia. There were no studies from East Asia.

4.2 Methodological approaches used

The methods breakdown for studies on women's technology adoption was:

- *Experimental*: Four studies (1 mixed methods, i.e., included a qualitative component). In three of these studies, randomization was conducted at the household level and in one study randomized at the farmer group level.
- *Quasi-experimenta*l: Eight studies (3 mixed methods). Across studies using quasi-experimental methods, two used difference-in-differences, four used a form of matching (propensity-score, nearest-neighbor, inverse-probability weighting) and two used instrumental variable estimation.
- *Non-causal assessments*: Seventeen studies (8 mixed methods). These studies used baseline and endline quantitative survey data to document changes in the context of the program or intervention (assessing contribution rather than attribution). Eight of 17 studies in this category were accompanied by qualitative data collection (focus-group discussions, interviews, participant observation).
- *Qualitative only*: 15 studies. Focus group discussions were the most commonly used qualitative method, used in 13 of the qualitative studies. Additionally, 10 studies used key informant interviews. Qualitative data collection in most of these studies took place within a short timeframe.
- Overall, 14 of 44 studies on women's technology adoption were classified as mixed methods.

4.2.1 How the WEAI tool was used

Only two studies used a version of the WEAI or related tools to measure empowerment outcomes. Of these studies, one used the WEAI and another one used the WELI.

Raghunathan et al. (2019) examined the effect of women's membership in a PRADAN self-help group on composite measures of empowerment using the WEAI, specifically the women's 5DE score and the gender gap in empowerment scores. Omondi et al. (2022) examined the effect of the WomenRear Project that provides livestock vaccine access on WELI indicators: autonomy in income; self-efficacy; respect among household members; input in productive decisions — livestock, ownership of land and other assets; control over use of income; access to and decisions about financial services; work balance; ability to visit important locations; group membership; and membership in influential groups.

4.2.2 Other outcomes analyzed

Forty-two studies measured technology adoption outcomes, but do not include a WEAI tool for this purpose. Most commonly included outcomes in these studies were adoption of new agricultural techniques; improved varieties of seeds; fertilizer; yield; farmer perceptions of agricultural technologies and varieties; gendered preferences related to livestock, beans, seeds; commercialization of varieties and agricultural practices; and women's labor and income. Most reviewed studies measured gender-heterogeneous impacts of technology adoption, but not empowerment-related outcomes.

Ten studies measured women's economic empowerment outcomes, as well as technology adoption outcomes. Women's economic empowerment outcomes analyzed in these studies include women's income and control over income, autonomy in decision-making related to forage, dairy and crop production and agricultural innovations, social network support, WELI and WEAI indicators, and women's recognition as livestock keepers.

4.3 Key findings and trends

4.3.1 Training interventions can positively impact women's technology adoption, but targeting plays an important role

Some studies suggested that training programs enhance women's technology adoption and empowerment. For example, a gender-responsive plant breeding and training intervention increased the adoption of improved varieties by women (Ndabashinze et al. 2024). In the Pan-Africa Bean Research Alliance (PABRA) program, the capacity-building component targeting women about bean management and nutrition benefited women and increased their self-confidence in the presence of men; the majority of women trained changed a number of practices on their farms (Katungi et al. 2020).

An innovation platform approach where farmers received improved maize seeds, inputs and training on agricultural practices, allowed women to increase their participation in the maize value chain and increased their income (Njingulula et al. 2020).

Targeting couples in training programs may be an effective strategy that needs further research. Lecoutere and Campenhout (2022) showed that intensive couples' coaching activities in farming as a household enterprise and participatory intrahousehold decision-making increased spousal cooperation.

An intervention in Ethiopia that trained beekeepers, improved hive designs and established input supply shops, increased adoption, and boosted women's participation, supported by technologies that simplified hive management and honey harvesting (Gebey et al. 2010). Gilligan et al. (2020) found that women's bargaining power plays a nuanced role in orange sweet potato adoption and diffusion. Adoption is highest on jointly controlled land where women lead crop decisions, while women with greater control over nonland resources are more likely to share orange sweet potato vines, promoting its spread. Neza et al. (2021) found that farmer field school trainings resulted in more shared roles between men and women in agricultural work, and higher women's decision-making at home and in groups.

Depending on the context, men may stand to benefit more from training interventions. Ronner et al. (2018) found that training farmers in improved climbing bean production practices, generally resulted in male farmers using more practices than female farmers. Aseete et al. (2023) showed that a public–private partnership for diffusing improved bean varieties was associated with a positive effect on productivity and revenue for male crop owners. Although women and men both benefit from improved technology availability and adoption

following the Improving Productivity and Market Success of Ethiopian Farmers' Project (Aregu et al. 2010), men tended to receive more information through agricultural extension and media. Also, women's crop variety preferences differ from men's. Women tend to choose varieties that are primarily used for domestic consumption, while men prefer varieties with high market demand and greater potential for higher prices.

Male-headed households were also more likely to practice climate-smart agriculture technologies (Kizito et al. 2019). Following training workshops designed to help male and female farmers understand probabilistic climate forecast information and management options, farmers with access to improved climate information reduced their cropped area, invested in more intensive crop management, and achieved higher yields. Gender played a role in shaping crop choices in response to climate information, with women favoring short-duration legumes. Additionally, women exhibited a lower willingness to pay for climate-related information compared to men (Rao et al. 2015).

Studies on livestock-related training programs showed a similar pattern. In a project using training tools to improve sheep and goat productivity (Kariuki et al. 2022), men exercised a greater ownership right compared to women, despite women's contribution to sheep and goat management. Lukuyu et al. (2020) examined an intervention targeting both men and women to promote the adoption of improved forages. The study found that men are mainly involved in land preparation and feed-related tasks, while women handle planting, weeding, and irrigation. Despite women's active role in forage production, they face gender disparities in accessing fodder markets and income, often losing out to men due to limited market information and weaker bargaining power.

4.3.2 Technological innovations may suffer from socio-cultural barriers in reaching women farmers

Women may benefit from technological innovations in livestock and crop varieties; however, socio-cultural factors can serve as barriers to fully realizing these benefits. In Malawi, Mudege et al. (2018) found that perception biases that regard the farmer as male, lead to women being overlooked in training programs. This undermines their ability to adopt new sweet potato technologies. Additionally, technology choices were influenced by access to land, irrigation systems, and labor — resources that women often lack. Moreover, activities like sweet potato vine multiplication increase women's workload, which can discourage adoption (Mudege et al. (2018).

Other research finds that benefits associated with new technologies are not equally experienced. For example, senior smallholders or men who have more education, connections, and the economic capital and support to try out new techniques benefit the most from improved pastures that are decisive in reducing greenhouse gas emissions (Ramos et al. 2024). In Uganda, Polar et al. (2022) found that sweet potato commercialization attracts mostly men, and women may be displaced in the trade.

Galiè et al. 2022 found that in many communities, improved livestock breeds and associated innovations, such as fodder choppers or training, are perceived as important for women, and women are recognized at a community level as livestock keepers. However, this recognition has increased women's burden.

4.3.3 Asset transfer interventions promoting technology adoption may create or reinforce gender disparities

The reviewed studies suggest the gender and social inequalities pose barriers to asset transfer interventions promoting women's technology adoption. Njuki et al. (2014) found that in Tanzania and Kenya in an intervention providing men and women access to and ownership of KickStart pumps, gender-equitable pump ownership was not achieved. Men dominated both pump ownership and major decisions on crops and income, with women accounting for only 10% of buyers. The study highlighted challenges for female-headed households, as the need for two people to operate the pump and cultural barriers hindered its use by women in some areas. Similarly, in Nepal, Shrestha et al. (2023) found that women's involvement in strategic decisions related to solar irrigation pump technology adoption, installation and usage was limited. The findings show the unequal social and gender relations that skew the adoption and benefits of solar irrigation pump technology.

A seed credit model in Uganda improved access to quality seeds for both women and men and led to increased productivity, income and decision-making power for women in crop sales; and participation in the model boosted women's skills, knowledge, and autonomy in bean production, enhancing economic empowerment and altering gender roles. However, men restricted women's access to land and labor to maintain control,

limiting seed quantity. The model also contributed to rising domestic violence, as some men felt threatened by women's economic empowerment. Over time, women's participation declined as they were required to repay their spouses' loans, while men's involvement dropped due to low repayment rates (Nanyonjo & Nchanji 2023).

Results from a project that distributed solar pumps and manual-lifting technologies to individual farmers in Ethiopia, Ghana and Tanzania showed that technology adoption costs and benefits can be unevenly distributed within households, with men holding stronger rights. In Tanzania, men control the sale of produce, limiting women's involvement in decisions about quantity, timing and pricing. In Ghana, women actively participate in marketing and negotiations, and both men and women view irrigation as empowering women to earn their own income (Theis et al. 2018).

In Uganda, Lukuyu et al. (2020) found that despite women's active involvement in the production of improved forages on smallholder farms, there is a gender imbalance in women's access to fodder markets and the income generated from the sale of planted forages. Men attributed this disparity to women's limited access to market information and weak bargaining power. The male dominance in the sale of fodder highlights how women are either excluded from or receive limited benefits from market participation.

4.3.4 Informational and knowledge dissemination interventions show promise in increasing women's technology adoption

A study by Raghunathan et al. (2019) found that women's membership in the PRADAN self-help group program improved access to information. The program provided agricultural knowledge, demonstrated techniques and organized women into producer groups. It also helped women negotiate better prices. However, it did not significantly increase the use of improved practices, crop diversity or the number of crops grown. Self-help group membership had large impacts on access to bank accounts, loan-taking behavior, and consumer- durable expenditure. Women also improved their decision-making power around agriculture, and the gender gap in empowerment within the household decreased.

Information and communication technologies (ICT)-based extension campaigns show potential in increasing farmer awareness and adoption of improved technologies. For example, a video-extension intervention featuring an aspirational story showed that targeting the female co-head alone increases her knowledge of recommended practices, her role in agricultural decision-making, and her role in the adoption of practices and inputs, and yields on her fields. In contrast, the male co-head's knowledge and unilateral decision-making decrease. When both co-heads are targeted, joint adoption of practices increases, and the male's unilateral decision-making is reduced. Female role models in the videos challenge men's stereotypes about women in agriculture and encourage women's adoption of practices. To empower women, focusing advisory services exclusively on the female co-head yields the most benefits (Lecoutere et al. 2023).

Following a gender-responsive digital extension intervention that included phone distribution, radio and SMS messages and information-sharing prompts, women were more likely than men to adopt new practices, highlighting their interest in, and need for, extension services. This is particularly important given that women face many of the same barriers to adoption as men — financial constraints, fear, and limited access to water — along with additional challenges like competing responsibilities, lack of training, and poor land access. These findings underscore women's typical exclusion from extension services and their eagerness to engage in activities traditionally offered to men. Phone ownership helped women access agricultural information, connect with their social networks, and improve their participation in household decision-making and production. The study recommends strengthening women's access to phones, targeting both spouses with information (including non-written formats), using sharing prompts, and providing more rigorous extension services on knowledge-intensive topics such as conservation agriculture and rural collectives (Ragetlie et al. 2022).

A radio program on beans targeting male and female farmers was associated with the adoption of practices related to planting, seeds, fertilizer, pests and disease management, weeding, harvesting, and storage for both women and men (Silvia et al. 2020).

5. Research gaps and directions for future research

5.1 Women's economic empowerment

5.1.1 Geographical scope and methods

Expand geographical focus of women's economic empowerment impact assessments. The majority of studies focus on South Asia and Sub-Saharan Africa, while low- and middle-income countries in Latin America, the MENA region and Eastern Europe are underrepresented.

Place greater emphasis on mixed methods. Only 25 of 80 studies on women's economic empowerment were classified as using a mixed methods approach. Future research should consider incorporating qualitative components to experimental and quasi-experimental studies. Qualitative research can capture nuances of empowerment that quantitative measures often overlook, especially if conducted over a longer duration (e.g., Galiè et al. (2017) conducted small-n exploratory research over five years to uncover the contextual and institutional circumstances that affect the empowerment of women farmers). In Breisinger et al.'s (2018) evaluation of Egypt's Takaful cash transfer program, some women initially provided the normatively prescribed answer when giving brief responses — stating that men make the decisions. However, their narratives revealed a different story. The qualitative study found evidence that the Takaful transfers empowered some women, particularly in households where the transfers were targeted to women, which increased their ability to make decisions about how to spend the money.

Diversify women's economic empowerment impact assessment research across CGIAR centers. Of the 80 studies included on women's economic empowerment, 50 are solely affiliated with IFPRI. Seven studies are collaborations between IFPRI and other CGIAR centers, including ILRI, IWMI, IITA and Landesa (external). Integrating gender into impact assessment studies needs to be strengthened across CGIAR centers, and greater collaboration across centers should be encouraged.

Strengthen causal impact assessments, particularly those using quasi-experimental methods. Of the 20 studies using quasi-experimental methods, 10 used matching methods with cross-sectional data. Matching methods rely on very strong assumptions, such as treatment selection based solely on observable characteristics, making validation uncertain when only cross-sectional data is available. Some studies misinterpreted "quasi-experimental methods", as they lacked causal inference techniques and counterfactual group. It is essential to enhance the use of validated quantitative causal inference methods (both experimental and quasi-experimental) and integrate qualitative methods to better triangulate the findings.

Expand women's empowerment measurement. Using the WEAI tools provides a standardized measure of women's empowerment. However, there are dimensions of women's empowerment that are captured in the WEAI tools, such as women's political participation, awareness and use of government entitlements, aspirations and forward-looking behavior, among others. These dimensions of women's economic empowerment are important to consider when planning future iterations of the WEAI. Most studies using a WEAI-based tool focus on versions like the pro-WEAI or A-WEAI. Only a few studies make use of alternative tools such as the WELI, WEFI, or WELBI. Depending on the intervention type and context, these other scales may be more appropriate.

5.1.2 Directions for future research

Future asset transfer interventions should seek to build women's self-efficacy via skill development, strategically involving men, and creating opportunities for enhancing social support networks. Studies on asset transfer interventions highlight the critical role of male support for women's empowerment

interventions, especially in patriarchal societies. Additionally, social support networks, particularly connections with other women, are vital components of empowerment. The impact of any single intervention on women's empowerment is likely to be limited, especially if it does not actively challenge the patriarchal norms that underpin gender inequalities. It is important that interventions do not inadvertently reinforce harmful gender norms, especially when working to close the gender gap in access to resources.

To truly understand empowerment dynamics, it is crucial to measure both tangible and intangible outcomes. Individuals may value intangible outcomes such as increased social capital or the preference to work inside the home given a hostile environment outside the home. While outcomes such as input use, production and sales may be more direct to measure, measuring intangible outcomes (e.g., self-esteem) is also key to understand empowerment dynamics.

Achieving sustained impacts on women's empowerment requires ongoing engagement within communities. Assessing the sustainability of these impacts should be an explicit goal of impact assessments and should be integrated into planning processes from the outset. In an ideal scenario, the impact assessment timeline should be sufficiently long to allow the program to be fully established and for beneficiaries to experience the intended duration and intensity of the intervention before assessing its impacts.

Formative research based on consultations with communities should inform how interventions are targeted. While gender-blind projects that define beneficiaries as households do not explicitly target men, they often benefit men disproportionately. At the same time, women-focused interventions can strengthen women's livelihoods, but create additional labor burdens.

Assessing the long-term impacts of training programs. Given the short time period of many studies in this review, the long-term impacts on women's economic empowerment were not assessed. Evaluating interventions after only a few years of implementation may not be long enough to assess uptake and behavioral outcomes. Future work should seek to understanding the mechanisms behind sustained impacts. Examining impacts on the use of women's time might shed light on unintended increases in workload. Complementary qualitative work on these issues would be valuable.

Identifying not only which are the most effective trainings but also what are the most effective training modalities is key. Studies on training interventions highlight the question of the optimal number of training sessions to include in nutrition-agriculture training programs. It would be valuable to conduct an ANGeL-type randomized controlled trial that varies the intensity of training to examine whether similar impacts can be achieved with fewer sessions, reducing the overall cost of the intervention. Modifying training modalities to account for other influential members within the household — such as mothers-in-law — is a potential area for future programming. In contexts where extended families are common and in-laws play a significant role in household decision-making, it may be necessary for extension delivery to consider intrahousehold and intergenerational dynamics.

Future assessments of nutrition-sensitive programs aimed at reducing poverty, food insecurity and undernutrition should consider women's empowerment as a key impact pathway. Recent gender- and nutrition-sensitive agriculture programs incorporate strong gender programming components, which have the potential to generate greater impacts on nutritional outcomes through women's empowerment.

5.1.3 Other considerations

Only a few studies in this review explored the unintended consequences of economic empowerment, such as intimate partner violence. A significant body of evidence links women's economic empowerment to backlash from male partners, often manifesting as violence. CGIAR research would benefit from examining these links specifically within the context of women's economic empowerment in agriculture.

The feminization of agriculture is a growing trend, largely driven by male migration for work opportunities. As men migrate, either temporarily or permanently, women are increasingly assuming responsibility for agricultural production and household management. While this shift may offer women more opportunities for involvement in the agricultural sector, it is important to study the broader impacts on women farmers, particularly in terms of their empowerment or disempowerment. Research is needed to understand how this shift affects women's decision-making power, access to resources, and control over income and assets. In

some contexts, the increased workload and responsibility could strain women's already limited time and resources, potentially exacerbating gender inequalities. Additionally, women may face challenges in accessing agricultural inputs, training and markets, particularly if male migration leads to weakened social structures or shifts in household power dynamics. Understanding whether the feminization of agriculture leads to women's economic empowerment or further disempowerment is crucial, as it can inform policies and interventions that support women's autonomy and well-being in rural agricultural contexts.

5.2 Women's technology adoption

5.2.1 Geographical scope and methods

Expand CGIAR's research to understand what works to improve technology adoption among women farmers. The total number of impact assessments reviewed on women's technology adoption is 44, significantly lower than the 80 studies focused on women's economic empowerment. During the keyword search, it was observed that many excluded studies either examined gender differences (and gendered preferences) in technology adoption, explored the determinants of technology adoption by women, or assessed impact on technology adoption without estimating heterogenous impacts by gender. Others investigated indicators like yield or women's and men's willingness to pay for technology, but did not focus on actual technology adoption. This highlights the need for more impact assessments specifically on women's technology adoption.

Expand the geographical focus of technology adoption impact assessments. The majority of studies on women's technology adoption focus on South Asia and Sub-Saharan Africa, while low- and middle-income countries in Latin America, the MENA region, and Eastern Europe are underrepresented.

Place greater emphasis on causal impact assessments, using experimental or quasi-experimental methods. Only 12 of 44 studies on women's technology adoption are classified as causal. Future research should consider implementing more experimental and quasi-experimental studies on technology adoption among women.

Expand the scope of outcomes to include women's economic empowerment. Most of the studies do not extend beyond women's technology adoption to women's economic empowerment. Only 10 studies examined women's economic empowerment in addition to technology adoption. Including women's economic empowerment outcomes in studies on women's technology adoption is key to understanding whether adoption leads to lasting empowerment. Given that very few studies assess impacts on women's economic empowerment, only two studies on women's technology adoption used a version of the WEAI (or similar) tool.

5.2.2 Directions for future research

Assessing the long-term impacts of training programs on women's technology adoption is an important area for future research. Due to the relatively short duration of many studies included in this review, the long-term effects on women's technology adoption were not assessed. To gain a deeper understanding of the adoption process, panel studies offer more valuable insights than cross-sectional surveys of farmers conducted at one specific moment in time (Ronner et al. 2018).

Research is required to assess different modalities for delivering extension services, specifically those that consider intra-household dynamics. While women play a crucial, often leading role in the decision to adopt technologies, this decision is typically made jointly with husbands. Given shared decision-making, the current approach of targeting only women for nutritional training may overlook an opportunity to raise awareness about the benefits of technologies among men. Engaging both adult household members may be the most effective strategy to encourage adoption (Gilligan et al. 2020). Policies that promote cooperation between spouses through gender-transformative household methodologies are recommended to improve welfare in agricultural households (Lecoutere & Campenhout 2022). Such interventions could help avoid potential unintended negative consequences of promoting women's exclusive control over resources and agency, such as jealousy, distrust, withdrawal of husbands from household responsibilities and domestic violence.

Some training interventions are effective in increasing women's technology adoption, yet more evidence is needed. An Innovation Platform approach that provided small-scale female producers with access to improved inputs such as seeds and fertilizer, and training and practical skills in maize production improved their participation in the maize value chain, mainly due to improved market access (Njingulula et al. 2020). In gender-responsive bean breeding initiatives in Burundi, the GREAT program training was essential for creating gender-responsive awareness among breeders and agronomists (Ndabashinze et al. 2024). Considering traits like cooking time and nutritional value that are important to women is critical. Site-specific commodity-based gender analysis is essential for understanding the different roles of women and men in the production of specific commodities, marketing and decision-making, their share in the benefits, identifying potential barriers for women's and men's participation in technology adoption; and what actions may be required to overcome these barriers (Aregu et al. 2010).

While the focus on removing barriers to women's adoption of technologies is well-intentioned, projects promoting technology adoption should recognize that the rights to these technologies can be subject to elite capture within the household. "Female-friendly technologies" are designed to ensure ease and comfort for women, but the right to use a technology does not necessarily grant other associated rights (such as fructus and alienation rights). Without these broader rights, the right to use the technology may simply result in an increased labor burden for women (Theis et al. 2018).

Extension programs should specifically target female farmers, either individually or alongside their spouses, but should not assume that targeting households will automatically result in benefits for women. Mudege et al. (2018) found that in a project introducing biofortified sweet potatoes, the male head of household was considered the primary farmer and targeted for training, while women were excluded from vine multiplication training, despite providing labor to produce the vines. Viewing women as cheap labor rather than active farmers with potential training needs and cash access constraints, limits their ability to adopt new technologies. Studies assessing the effectiveness of different targeting approaches are key in future research.

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