A farmer in Kibirichia area, Kenya, uses a mobile phone. Photo: ©2010 CIAT/NeilPalmer, CC BY-SA 2.0

# Chapter 4

## Solutions for digital inclusion and digital innovations for inclusion by 2050

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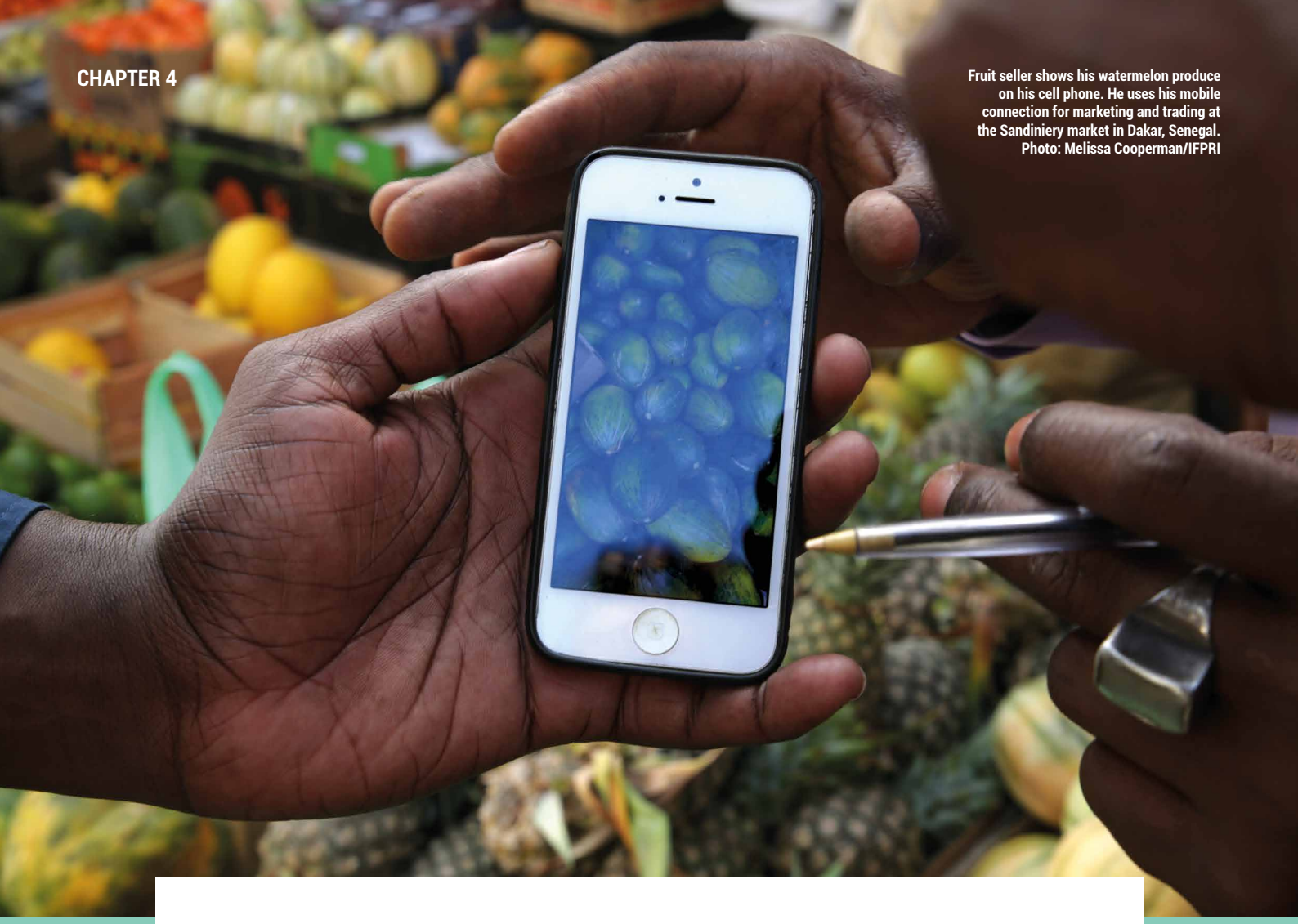


Fruit seller shows his watermelon produce on his cell phone. He uses his mobile connection for marketing and trading at the Sandiniery market in Dakar, Senegal. Photo: Melissa Cooperman/IFPRI

## Key messages

- Digital technologies are increasingly shaping how people access information, climate and advisory services, finance, markets, jobs, public services and governance in food, land and water systems — a trend that will accelerate toward 2050.
- Investing now in digital inclusion is essential to building a more equal food, land, and water systems future, so women, youth and socially excluded groups can participate in, benefit from and shape digital transformation.
- Digital transformation will not be inclusive by default. If the norms, institutions, markets and data systems that shape digital innovation reproduce existing inequalities, women, youth and socially excluded groups risk being left behind.
- Digital inclusion in food, land, water systems hinges on agency: the power to access, control, trust, use, shape, adopt, reject and benefit from digital and AI tools in ways that support livelihoods and collective interests.
- Promising pathways combine participatory design, bundled services, multimodal delivery, peer networks, women's groups and cooperatives, alongside stronger legal and institutional governance that protects rights, builds trust and gives users control over their data.

# 4.1. CURRENT STATUS AND FUTURE OUTLOOK

As chapter 1 demonstrates, **food, land and water systems** (FLWS) are transforming unevenly: **off-farm work** is expanding, **youth** employment in agriculture is falling in most regions, and women's participation and earnings remain shaped by persistent regional gaps. Digital technologies will increasingly mediate information, finance, markets, advisory services and governance in these changing systems.[1] Inclusive digital systems could lift approximately 30 million women out of extreme poverty and add around US$1.5 trillion to the global economy by 2050,[2] but these gains depend on who can access, control, trust and shape digital systems. In South Asia and sub-Saharan Africa, mobile-ownership and internet-use gaps remain slow to close.[3] This chapter asks which **digital inclusion** strategies can support **gender** and intersectional equality in FLWS by 2050, and under what conditions. It draws on chapter 1 projections to frame future priorities, while recognizing that comparable long-term, gender-disaggregated **digital agriculture** projections remain limited. This chapter is situated within the report's wider framing of the **polycrisis**, set out in the introduction along with the report's conceptual framing. The methods employed across the thematic chapters are documented in annex A and key terms are fully defined in annex B. This chapter focuses specifically on how digitalization may either reinforce exclusion or expand **agency** in future FLWS.

Digital inclusion is concerned with ensuring that the design, deployment and governance of digital technologies are fair, equitable and socially responsive. Dominant approaches often track inclusion through connectivity, affordability, skills, usability and adoption.[3,4] These dimensions are necessary, but they do not fully explain who controls devices and accounts, whose knowledge is represented or who can translate digital information into action. Building on the **Gendered Food Systems Framework**[5] and feminist analyses of agrarian technologies,[6] this chapter distinguishes three interdependent dimensions of digital inclusion: accessibility, usability and agency.

In this chapter, **digital accessibility** refers to the baseline conditions that allow users to reach and connect to digital services. In FLWS, digitalization is often framed as a way to reach the last mile, reduce distance and transaction costs, and extend advisory, financial, market and public services to underserved populations. This framing remains important. Without affordable devices, connectivity, electricity and data, digital services cannot reach rural users at scale.

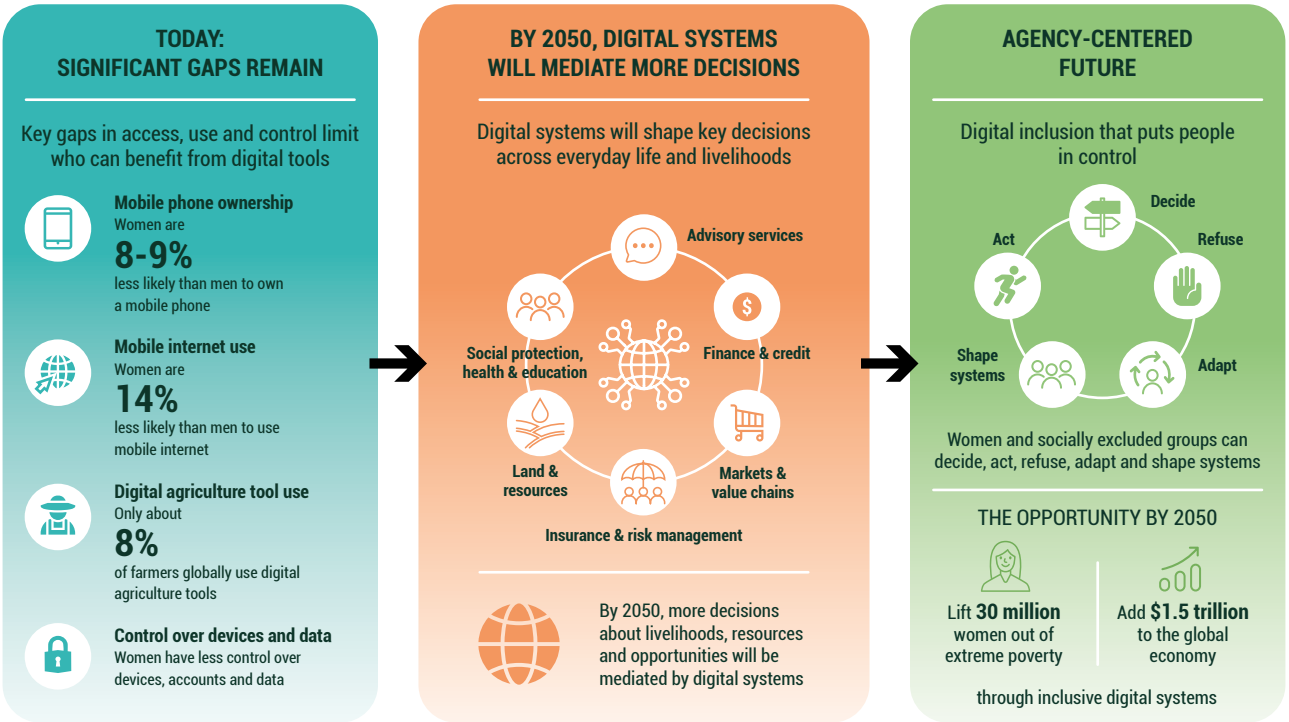
Access is shaped by markets, policy incentives, household relations, affordability and social norms. As chapter 1 shows, women are about 8–9% less likely than men to own a mobile phone and around 14% less likely to use mobile internet, with the largest gaps in South Asia and sub-Saharan Africa.[3,7] These gaps intersect with education, income and geography: in Kenya, phone ownership ranges from 98% among women with more than secondary education to 63% among women with no education; while in Liberia, urban women are more likely than rural women to own phones and smartphones.[8,9] Evidence is stronger on gender, education, age and rural location than on disability, ethnicity, caste, migration status, Indigenous identity, language and other axes of social exclusion. This is an evidence gap, rather than evidence that these differences do not matter. Looking toward 2050, persistent access gaps may reproduce old exclusions through digital advisory, finance, insurance, traceability, land administration, markets and **social protection** systems. Shared phones, unregistered SIM cards, account monitoring and household control over data costs can further limit meaningful access.[7]

Usability refers to whether users can understand, navigate and effectively engage with digital technologies once access exists. It depends not only on interface design, but also on time, literacy, digital skills, safety, privacy, trust, language, connectivity and support to learn and experiment.[3,4] Digital services often assume that clear information and ease of interaction will translate into uptake,[10,11] but adoption patterns suggest that access and interface design do not automatically translate into sustained or meaningful use. Only about 8% of farmers globally use digital agriculture tools, with adoption rates around 5% in sub-Saharan Africa, 6% in Southeast Asia and 10% in South Asia[12] (suppl. material figure S1).[i]

Relevance is central to usability. Many digital agriculture services are designed around production-focused decision-making and formal farm management, while women's roles in processing, food services, informal trade, lower-return market activities and care-linked FLWS work often remain less visible in data, design and advisory content.[12,13,14] **AI**-enabled systems trained on datasets that underrepresent women's crops, livestock activities, local knowledge and informal market roles may generate less relevant recommendations. Evidence from AI-based advisory platforms and large language model evaluations shows that **algorithmic bias** — in language, referral, data and alignment — can produce uneven responses to women farmers and gender-related queries.[15,16,17]

i) See online *Supplementary material: Chapter 4*, https://hdl.handle.net/10568/185642.

*From today's gaps to an agency-centred, inclusive digital future*




## Figure 20. The digital divide today and why agency matters by 2050

*Sources: GMSA,[3] ITU,[4] Beanstalk AgTech,[12] World Bank[21]*

These challenges point to agency, which refers to the ability of individuals and communities to make decisions about technology use and to influence how technologies are designed, governed and implemented.[18] Digital inclusion is, therefore, not only about providing access or improving usability. It is about whether users can shape digital services, act on the information they receive, refuse unsafe or inappropriate technologies and derive meaningful benefits from digital engagement.

Focusing on agency shifts the discussion away from viewing users as passive recipients of innovation. Technologies rarely unfold in practice as designers imagine.[19] Farmers and rural communities adapt tools to local needs and conditions, often through social networks and intermediaries that shape how technologies are interpreted and used.[11,18,20] Agency, therefore, includes adaptation, negotiation, selective use and refusal, including informed refusal where technologies create risks of surveillance, bias, irrelevance, household conflict or unfair data terms.

The ability to exercise agency is shaped by structural conditions beyond individual users. Digital markets and service providers often prioritize users who are easier and less costly to serve.[12,21] In gendered agrifood **value chains**, women may participate heavily but remain concentrated in lower-return segments with weaker access to information, assets and decision-making power.[22,23] In coffee value chains, women are often involved in harvesting and processing, while men more often control storage, pricing, formal marketing and sales decisions.[23] Land ownership, **time poverty**, mobility constraints, **unpaid care work** and limited control over resources further shape whether women can act on digital information.

AI and data-intensive systems make agency more urgent for 2050. AI systems can reproduce existing inequalities in how information is prioritized, whose needs are recognized and whose knowledge is treated as valid.[24] Privacy and surveillance risks are significant where women rely on shared devices or have limited control over accounts and personal data. In Kenya, women are 15–25% less likely than men to access **digital climate advisory services** due to **structural barriers** including device ownership, literacy and social norms.[25] These constraints affect not only access to information, but the conditions under which information can be trusted and used.

Accessibility, usability and agency are dimensions of digital inclusion that form the chapter's core conceptual framework. They should not be understood as sequential steps, but as interdependent conditions shaped across levels. Accessibility concerns whether people can reach digital services through devices, connectivity, affordability, electricity and data. Usability concerns whether those services are relevant, understandable, trusted and supported through local languages, appropriate design and assistance. Agency concerns whether women, young people and **socially excluded groups** can decide whether and how to use digital technologies, act on digital information, refuse unsafe or inappropriate tools, adapt technologies to local needs and influence how digital systems are designed and governed.

Agency is, therefore, not an individual attribute alone. It is embedded within social, economic and institutional contexts.[26] At the individual and household level, agency depends on privacy, control over devices and accounts, confidence, time, resources and the ability to act on information. At the community and institutional level, it depends on trusted intermediaries, women's groups, peer networks, extension systems and feedback channels that make digital services usable and accountable. At the systemic level, it depends on policies, markets, **data governance**, AI accountability, financing and institutional rules that determine whose knowledge is represented and who can contest digital decisions. Digital inclusion therefore requires the earlier and more substantive involvement of farmers in design, testing, governance and evaluation. Rather than designing for smallholder farmers as a generic user category, inclusive digital transformation requires designing with women, young people and socially excluded producers, building from their priorities, constraints, knowledge and existing practices.[27,28,29]

This framework informs the four pathways discussed below. By 2050, meaningful digital inclusion should be judged not only by access, adoption or short-term use, but by whether digital systems expand people's ability to decide, act, refuse, adapt and shape the technologies that increasingly mediate FLWS livelihoods.

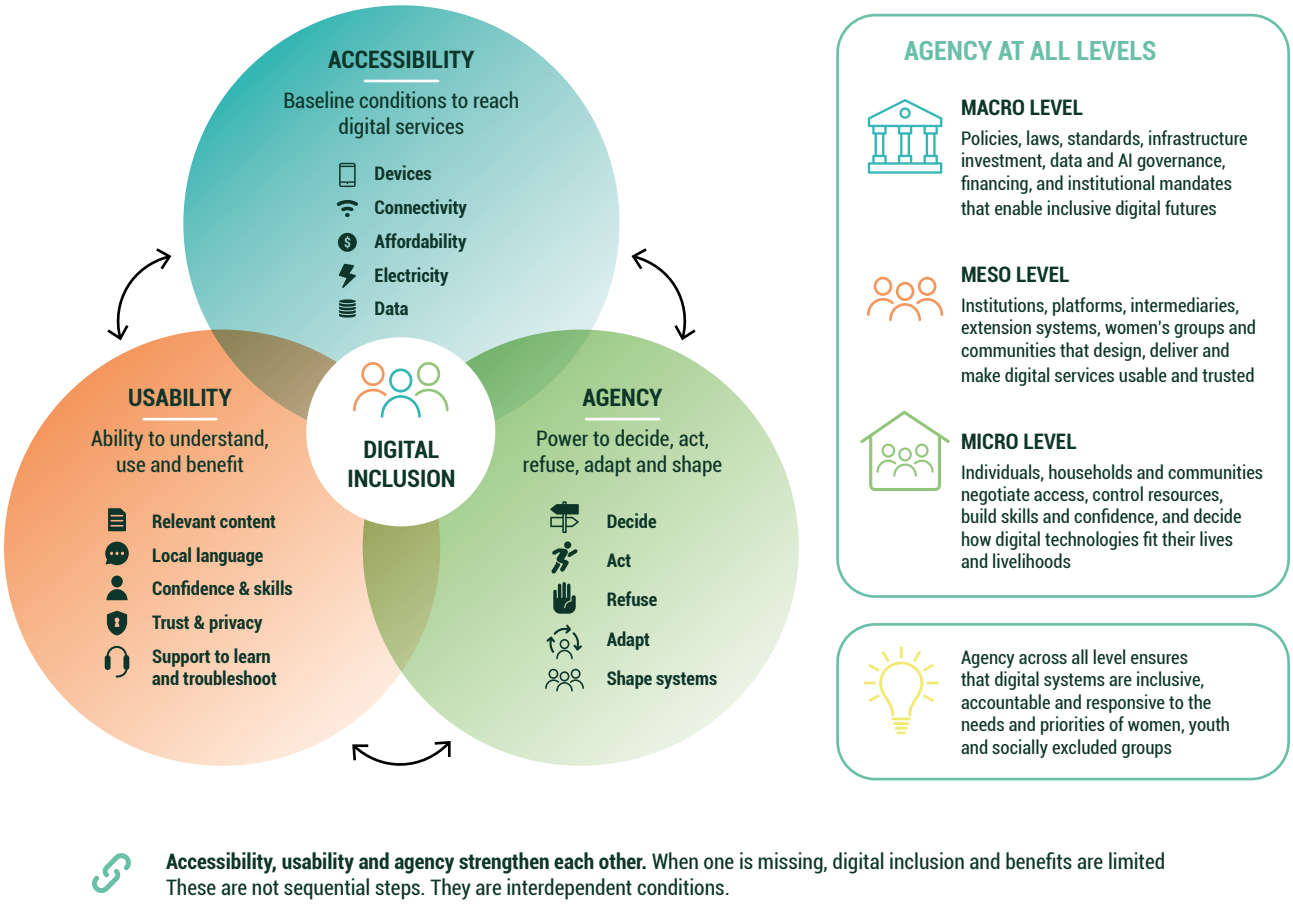



Figure 21. Three interdependent dimensions of digital inclusion

Young women use a phone for mapping in Kassena-Nankana District, Ghana. Photo: Axel Fassio/CIFOR, CC BY-NC-ND 2.0

# 4.2. PATHWAYS TO EQUALITY AND INCLUSION

Building on the centrality of agency, barriers to digital inclusion are embedded within overlapping systems that operate across individual and systemic levels, and across formal and informal domains. Digital exclusion, therefore, arises not from a single constraint, such as lack of connectivity, but from the interaction of multiple constraints that shape access, use, interpretation, governance and the ability to act.

This section organizes pathways to agency-centered digital inclusion across four interrelated domains: systemic–formal factors, including infrastructure, markets, policy frameworks and governance; systemic–informal factors, including norms, trust and networks; individual–formal factors, including devices, connectivity, skills and linked resources; and individual–informal factors, including confidence, legitimacy and decision-making power. These pathways operate differently across age, disability, caste, ethnicity, Indigenous identity, migration status, language, location and class. The report uses **Reach, Benefit, Empower, Transform** (RBET) as an evidence lens to distinguish between interventions that expand coverage, generate benefits, strengthen agency or shift the conditions that reproduce exclusion.

## 4.2.1. Systemic–formal pathways

Systemic–formal pathways shape the conditions under which digital technologies are accessed, used, financed and governed. Infrastructure remains essential: investments in broadband, electricity, connectivity, shared infrastructure and community access points can reduce geographic inequalities in digital access. In rural Senegal, electrification increased women's mobile phone ownership from 45% to 70%.[30] Peru's Internet para Todos and regulatory sandboxes in Colombia show how shared infrastructure and regulatory innovation can expand rural connectivity.[31] Affordability also matters: in rural Assam, reducing smartphone data costs increased women's internet use and engagement with digital content.[32]

Policies determine whether infrastructure gains translate into inclusive participation. National strategies with gender targets, rural investment, affordability measures and sex-disaggregated monitoring can make exclusion visible and shift incentives within digital ecosystems.[33] In India, linking digital tools with local governance institutions improved women's engagement with public services

and digital payments.[34] These examples show that digital inclusion depends on institutional delivery systems, not only technical supply.

By 2050, systemic–formal inclusion will depend increasingly on data governance. Digital advisory, credit scoring, insurance, traceability, land registries and subsidy systems are becoming more data-intensive, creating opportunities for better targeting and service integration while raising questions of ownership, consent, privacy, value capture and accountability. Reviews of smart farming data governance, agricultural data ownership, and **data sovereignty** highlight gaps in privacy, transparent governance, farmer awareness of data rights, enforceable control over data use and recognition of farmers' data as an asset linked to innovation, equity and livelihoods.[35,36,37]

Under current trajectories, digital systems may expand while governance remains concentrated in states, donors, agribusinesses and technology providers. Women may become more visible to digital systems without gaining control over how their data are collected, interpreted, reused or monetized. This risk is acute where women use shared devices, lack control over SIM registration or cannot correct records that affect eligibility, pricing, credit scores or recommendations. Expanded reach can, therefore, coexist with algorithmic exclusion.

An agency-centered 2050 pathway would treat governance as part of inclusion. Women farmers and their organizations would be represented in decisions on data use, model updating, consent, auditability and redress. Women-led data cooperatives, data trusts, producer organizations or rights-based public data institutions could negotiate whether farm, household, location, financial and behavioral data can be shared, anonymized, monetized or withheld. Such arrangements would need safeguards against open data or platform models that extract value without shifting power over data use and benefit-sharing.[38,39] Emerging work on socially inclusive and **gender-responsive** AI design in African agriculture suggests that involving farmers and local actors in design processes can improve relevance, responsiveness and attention to risks.[40] By 2050, the same principle should apply to data governance, AI accountability and platform regulation.

## 4.2.2. Systemic–informal pathways

Systemic–informal pathways include **gender norms**, social expectations, trust and **community institutions**. These shape how digital technologies are interpreted, negotiated and acted upon within households, communities and social networks. Digital information rarely leads directly to action: farmers compare advice with local knowledge, assess credibility, discuss risks and negotiate decisions with others. Information becomes actionable when embedded in trusted relationships.

Social networks and collective action play a central role in digital engagement. In Uganda, ICT-mediated extension directed to women strengthened knowledge and participation in decision-making, though outcomes depended on household negotiation.[41,42] Participatory radio, peer interactions, edutainment and couple-based interventions can support collective interpretation and household discussion, while evidence from Malawi shows that women communicators were as capable as men but less likely to be perceived as credible.[43,44,45,46,47,48]

Collective delivery can strengthen agency when it shifts interpretation and decision-making power. Digital Green's[ii] video-mediated extension model works through **community-based organizations** and women's self-help groups; an evidence review found that female-facilitated screenings were associated with higher adoption than male-facilitated screenings.[49] The Small Farmers Large Field model in Khanizpur, Odisha, similarly organized 35 landless women tenant farmers across 38 acres and 111 plots, increasing yields, shifting average per-acre net returns from loss to profit and reducing labor requirements.[50]

Under current trajectories, many digital services are designed around an individual user who receives information privately and acts independently. This obscures the collective and negotiated character of FLWS decision-making and can shift mediation power toward men, local elites or better-connected farmers. An agency-centered 2050 pathway would recognize women's groups, savings groups, cooperatives and producer organizations as trusted intermediaries and co-designers, embedding digital services in spaces where members collectively interpret AI-generated recommendations, compare them with local knowledge, assess risks and decide whether and how to act.

## 4.2.3. Individual–formal pathways

Individual–formal pathways focus on devices, connectivity, skills and complementary resources provided through structured programs. Access to devices and connectivity matters most when combined with onboarding and practical support. Programs such as India's Internet Saathi, mobile training initiatives in Bangladesh, smartphone provision in Chile and digital skills support through PlantwisePlus in Nepal, Ethiopia and Uganda show that structured support can expand access, confidence, engagement with extension services and participation in

ii) See Digital Green's website and IDinsight's blog post summarizing the project, "Supporting Digital Green: bringing tech-enabled solutions to agricultural extension."

decision-making.[32,41,42,51,52] Yet advice alone does not create room for action when women lack cash, inputs, time, transport, land documentation or authority over spending.

For this reason, individual–formal pathways need service bundles, not stand-alone tools. Mobile money and digitized transfers can strengthen financial inclusion and bargaining power when women retain control over accounts and SIM cards.[32,53] Gender-inclusive extension for an insurance-linked credit product in Kenya improved farmers' understanding and willingness to pay.[54] The Digital Agricultural Innovations and Services Initiative framing paper similarly shows that farmers often need linked support across information, finance, inputs, markets and risk management.[55] In Odisha, KhetScore used digital technologies and remote sensing to expand credit and insurance access for small and marginal farmers, with treated farmers, especially women, more likely to obtain insurance and borrow from formal sources.[56]

Under current trajectories, women may log into an app, receive notifications or complete a transaction while services remain designed around an assumed male landholder, formal farmer or commercially connected producer. Advisory messages may tell women what to do without linking them to credit, insurance, inputs, extension, land documentation, markets or public entitlements. An agency-centered 2050 pathway would make digital advisory a gateway to negotiated bundles of support. A woman farmer receiving climate advice should be able to compare seed options, check insurance terms, assess subsidy eligibility, access group-based credit, review market conditions and decide what data to share. Agency includes the ability to use services, compare options, decline offers and withhold data where terms are unfair.

## 4.2.4. Individual–informal pathways

Individual–informal pathways shape confidence, aspirations, legitimacy and decision-making power. Current approaches to digital literacy often remain too narrow. Many programs train women to operate devices, follow platform instructions or navigate applications. These skills matter, but they do not by themselves produce agency. A woman may learn to use an app and still lack the confidence to question a recommendation, seek a second opinion, challenge a household decision or bring her priorities into an advisory interaction.

Existing evidence points toward a broader approach. In Uganda, directing agricultural information to women strengthened knowledge and participation in decision-making, while role-model effects helped challenge gendered perceptions of women as technology users and decision-makers.[41,42] In Tunisia, a gender-responsive digital extension intervention combining phone distribution, radio, SMS messages and information prompts examined how **digital advisory services** can address gender gaps in access, use and benefit from ICT-mediated extension.[48] Group-based training and delivery through women's organizations, including Self-Employed Women's Association-linked approaches, can create supportive environments that reduce stigma and enable experimentation.[32] Women's groups, listening clubs and WhatsApp networks also provide spaces for reflection, encouragement and peer interpretation.

Work on digital empowerment frames competence as a combination of knowledge, skills and attitudes, not only operational ability.[57] Agricultural digital literacy reviews and gender-focused AI analyses show that adoption and participation depend on digital skills, socioeconomic context, cultural barriers, **representation**, design and governance, not access or training alone.[58,59]

Under current trajectories, digital literacy may produce compliant users who can follow instructions but have limited capacity to question systems or shape outcomes. It may also treat hesitation as a problem, even when caution reflects informed judgment about surveillance, bias, irrelevance, poor data terms or household conflict. An agency-centered 2050 pathway would treat literacy as a route to confidence, interpretation, critique and experimentation, combining phone use with AI advice interpretation, financial planning, safe account practices, data rights, peer mentoring and local women role models.

## 4.2.5. Enabling conditions and transferability

The examples reviewed in sections 3.1–3.4 draw on a targeted scoping review of peer-reviewed articles, working papers and practitioner or policy reports.[iii] Across the four pathways, digital inclusion emerges from the interaction of infrastructure, affordability, skills, institutional delivery, governance and social norms. The evidence reviewed above suggests that bundled and multimodal approaches are often more effective than stand-alone interventions because they combine formal provision with informal support systems.[32,42,48]

Transferability depends on whether approaches can be adapted to local institutions, norms, languages, delivery systems and resource constraints, rather

iii) Table 1 in this chapter's online *Supplementary material* maps the range of approaches reviewed rather than providing a systematic review or meta-analysis of effects. https://hdl.handle.net/10568/185642

than replicated as fixed technologies. Data and AI governance are also part of the enabling environment. Digital systems can reproduce extractive relationships in which smallholders, including women, are treated as data providers rather than data holders.[60] **Findable, Accessible, Interoperable and Reusable (FAIR) principles** support technical data sharing,[61] while **Collective Benefit, Authority to Control, Responsibility and Ethics (CARE) principles** foreground collective benefit, authority to control, responsibility and ethics.[62,63] AI governance must also address language bias, referral bias, weak gender benchmarking, privacy, transparency and accountability.[15,16,17,24] RBET can help distinguish promising entry points from interventions with stronger evidence of **empowerment** or transformation; where control over devices, accounts, data, resources, decisions and feedback channels is not measured, claims about transformation should remain cautious.

Figure 22 summarizes the four pathways through which agency-centered digital inclusion can be strengthened. The pathways are not separate solutions, but complementary entry points. Systemic–formal pathways concern infrastructure, policy, markets, data governance and AI accountability. Systemic–informal pathways concern norms, trust, community institutions and collective interpretation. Individual–formal pathways concern devices, skills and linked services such as finance, inputs, insurance and advisory support. Individual–informal pathways concern confidence, role models, peer learning and critical digital literacy. Across all four pathways, the priorities are **intersectionality**, safety, **co-design**, accountability and sustainability.

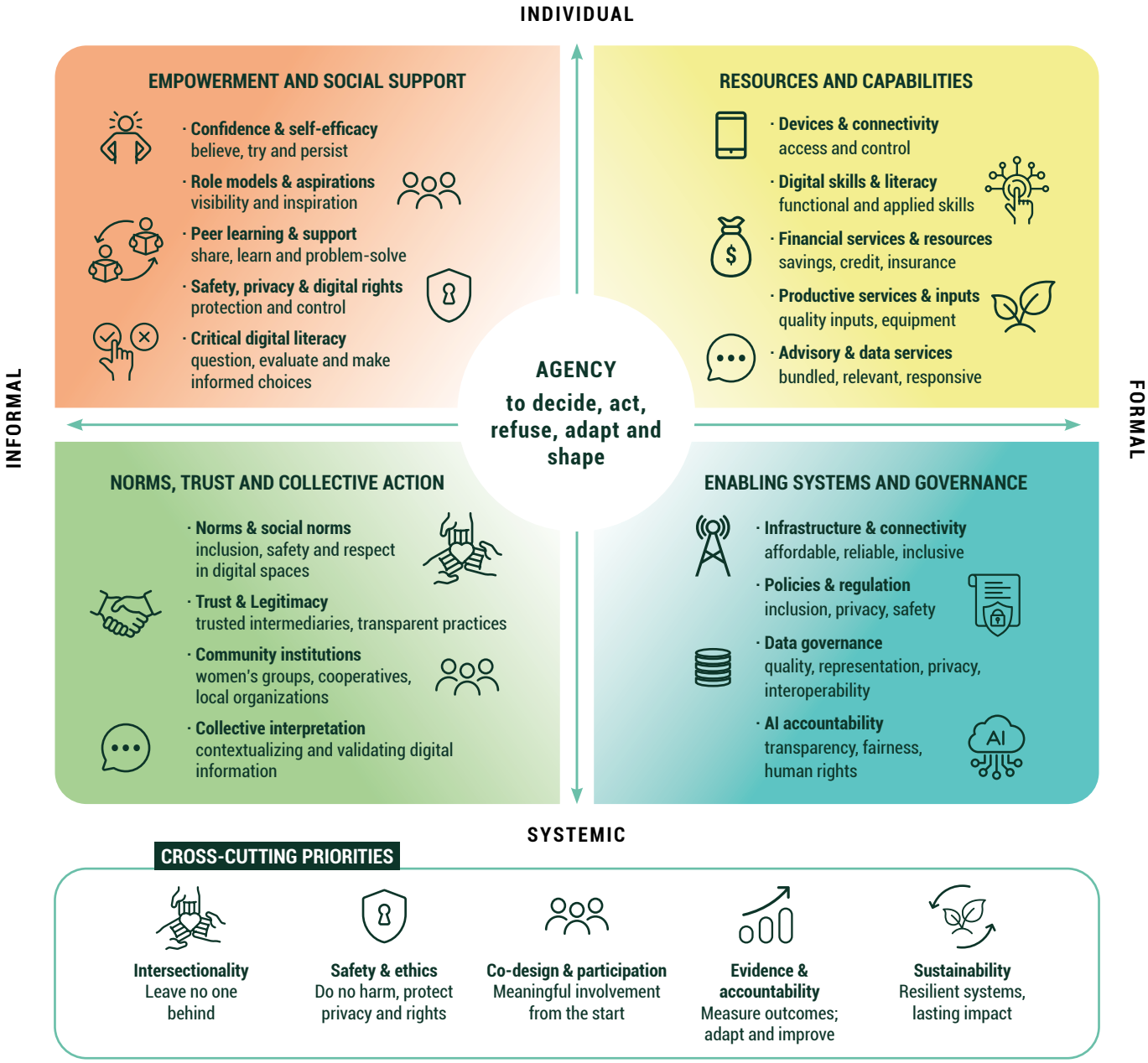



Figure 22. Pathways and priorities for agency-centered digital inclusion

A woman farmer in Odisha, India, uses a mobile phone application in partnership with a technical advisor in a farmer producer company.
Photo: N. Ronoh/CGIAR, CC BY-NC-ND 4.0

# 4.3. PRIORITY ACTIONS

Priority actions for translating digital inclusion into practice by 2050 — placing agency at the center — require reshaping systems that address accessibility, usability and agency together, rather than developing isolated tools. Outcomes are shaped not by technology alone, but by how infrastructure, institutions, capabilities, data governance and social norms interact. Different actors have distinct roles: researchers should build agency into evidence and measurement; practitioners and technology developers should design multimodal, low-bandwidth and locally relevant services with users; governments should set data, AI and inclusion safeguards; and investors and partners should fund shared infrastructure, trusted intermediaries and long-term accountability systems.

## 4.3.1. Research

Research priorities should begin from the recognition that farmers are not a homogeneous group. Their experiences of agriculture and digital technology are shaped by intersecting social positions, including gender, age, education, literacy, location, disability, class, caste and ethnicity. These identities influence how they produce and share knowledge within agricultural networks increasingly mediated by digital infrastructures. Too often, inclusion is treated as a downstream adoption problem: whether women and other socially excluded farmers have phones, connectivity, literacy or confidence to use a tool. These barriers matter, but research needs to move further upstream by asking how diverse farmers' needs, aspirations, constraints and expertise shape technologies from the beginning.[17]

A first priority is to understand diverse farmers as differentiated users of technology.[6,40,64] Research should examine how gendered responsibilities, time poverty, mobility constraints, household bargaining dynamics, social networks, language and migration status shape what kinds of digital and AI tools are useful, usable and safe. Current evidence documents important differences by gender, education, age and geography, but less is known about how these dimensions interact to shape digital opportunities and exclusions.[3]

A second priority is to study how intersectional identities are represented within data systems and

**digital public infrastructure**. AI-enabled advisory tools, land registries, credit scoring systems, insurance platforms, input delivery systems and social protection platforms can expand access, but they can also reproduce exclusion when women, Indigenous communities, migrants, persons with disabilities or low-resource language speakers are poorly recorded or misclassified. Research should ask what kinds of gendered agricultural knowledge are captured, what is excluded, who controls the data and how classifications shape access to services.[38,39,60] It should also examine how Indigenous, local and traditional knowledge systems are represented within AI-enabled FLWS systems. Many AI models rely on written, digitized, and standardized information, which means that oral traditions, experiential knowledge and place-based practices may be overlooked or misrepresented.[62,65]

A third priority is to improve measurement. Many programs demonstrate reach and short-term benefits, but fewer capture sustained changes in agency, decision-making power, norms or institutional accountability.[66,67,68] Frameworks such as RBET provide a foundation but need further operationalization across contexts. Indicators should track control over devices and accounts, ability to act on information, participation in service design, contestation of digital records and influence over data governance. Longitudinal and mixed-methods research is needed to understand whether digital interventions shift power over time, particularly for women, youth and socially excluded producers.[25,68,69]

By 2050, research should embed agency into digital agriculture from the outset. Women and other socially excluded farmers should help define research questions, validate advisory recommendations, identify risks and shape the data categories and safeguards that influence access to services. This requires reimagining the relationship between gender equality and **social inclusion** research and technology design: success should be measured not only by adoption, but by whether digital systems strengthen farmers' decision-making power, resource access and authority within agricultural knowledge systems.

## 4.3.2. Policy

Policy priorities should focus not only on regulating AI or promoting agri-tech adoption, but on building the institutional conditions that allow digital innovation to improve FLWS responsibly. Evidence from Indian agri-tech startups shows that nontraditional entrants were able to innovate by accessing publicly accumulated agricultural knowledge through universities and research institutes. Their success depended less on capital or farming experience than on institutional links that enabled knowledge recombination across agriculture, engineering and AI.[70]

For CGIAR, the strategic advantage lies in stewarding this shared knowledge architecture: curating decision-grade evidence, translating research into machine-operable rules and safeguards, and working through partnerships with national agricultural research and extension systems, ministries, extension services, universities, farmer organizations and local intermediaries.[17,71,72]

A core policy priority is data and AI governance. Governments and regulators should make gender and intersectionally disaggregated monitoring, grievance redress, data protection and independent bias checks part of digital agriculture and AI programs. Public institutions should require gender-responsive impact assessments across the AI life cycle, including attention to how advisory tools affect women's access to land, credit, inputs, extension, social protection and decision-making power. Policies should require transparency about data provenance, consent, ownership, and reuse and should protect against systems that make women, migrants, Indigenous communities, persons with disabilities or low-resource language speakers invisible.[17,65,73,74,75]

Policy must also address the delivery systems that turn data into usable services. Frameworks such as National Frameworks for Weather, Water and Climate Information Services show how data production, service delivery and user engagement can be aligned.[76] Similar coordination is needed for digital agriculture — where advisory, finance, insurance, markets and public services increasingly intersect. Financing should support infrastructure, capacity development, local-language systems, inclusive benchmarking and long-term monitoring of who benefits and who is excluded.[77]

By 2050, AI policy for agriculture should center on public knowledge infrastructure rather than isolated tools. Public institutions can steward validated evidence, decision rules, safeguards and feedback systems, while SMEs, cooperatives and service providers build locally useful interfaces. The goal is advisory sovereignty: AI-enabled services whose evidence base, safeguards, feedback systems and accountability mechanisms remain answerable to the people whose livelihoods they affect.

## 4.3.3. Practitioners and private sector

Practice should move from technology deployment toward integrated, context-responsive service systems. Digital advisory systems are most effective when users have the resources, capabilities and institutional support needed to act on information.[69,78] This requires bundling digital services with finance, inputs, insurance, markets, training and extension support rather than treating information as sufficient on its own.[67,79,80,81]

Delivery systems also need to be multimodal. Combining digital platforms with radio, voice messaging, extension services, group learning and community-based approaches improves reach, usability and sustained engagement.[82] This is especially important where literacy, language, connectivity, mobility or norms restrict engagement. As chapter 1 shows, in South Asia, where female labor force participation remains low and digital gaps remain large, delivery through women's groups, local governance institutions and trusted intermediaries may be essential. In sub-Saharan Africa, where agricultural employment remains high and population growth is rapid, digital services need to support both farm productivity and off-farm opportunities.

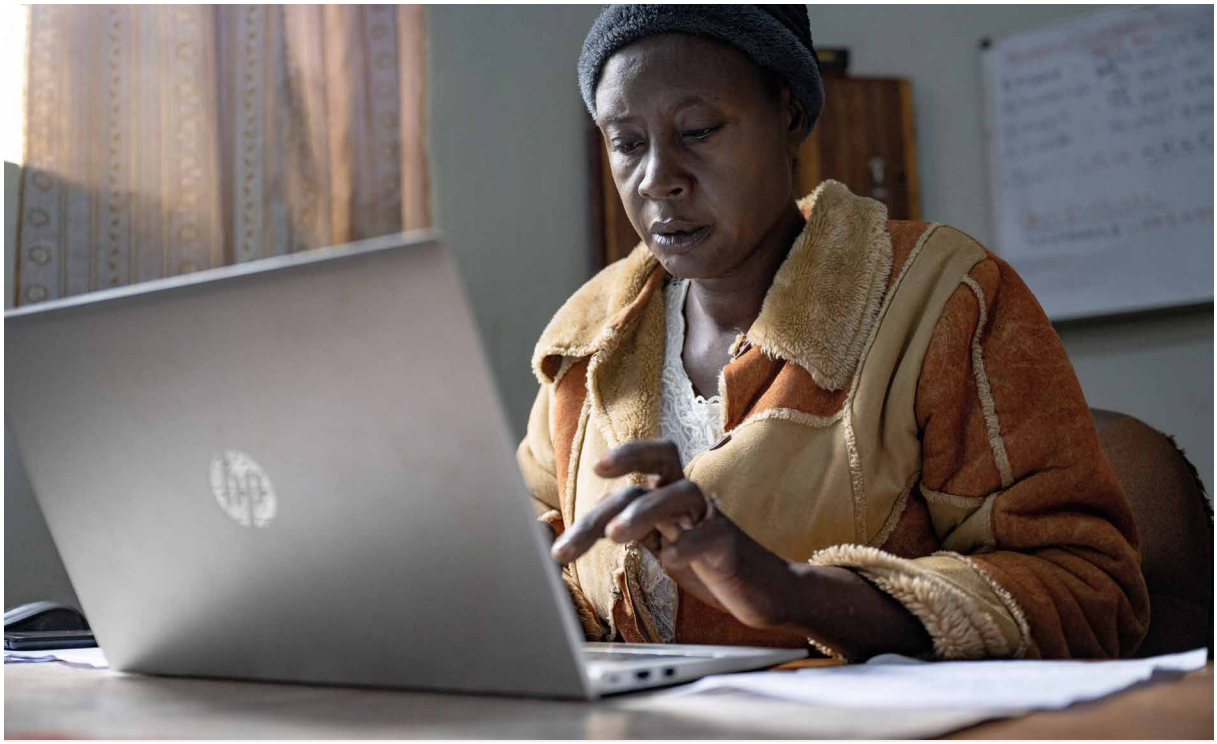
Co-design and iterative learning should become standard practice. Services are more effective when developed with users and adapted to local conditions.[68,83,66] Technology developers and private providers should test tools with women, youth and socially excluded users before **scaling**, and build in low-bandwidth access, local-language content, privacy safeguards and human support. Extension workers, farmer organizations, cooperatives, women's groups, local SMEs and civil society organizations help users interpret information, assess risks and provide feedback. Practice should therefore invest in the people and institutions that make digital systems trusted and actionable, not only in platforms.

AI should be used as accountable public-interest infrastructure rather than treated as a productivity mandate. It can reduce administrative burdens, support translation, clean data, synthesize literature and improve advisory services, but only where privacy, consent, human oversight and inclusion checks are built into everyday workflows.[17,74] Responsible practice should document data provenance, assess consent for secondary data use, test tools for bias and harm, and evaluate outcomes beyond downloads or usage statistics to include trust, explainability, empowerment, risk and changes in access to resources.

## 4.3.4. Investments and partnerships

Inclusive digital transformation requires partnerships across public, private, research and community actors. Public institutions can set enabling policy environments and invest in infrastructure. Research institutions can generate decision-grade evidence, support co-design and evaluate impacts. Private firms and SMEs can contribute technical innovation and delivery capacity, provided that interoperability, data rights and social inclusion safeguards are built into agreements from the beginning.[71] Funders and donors should prioritize shared infrastructure, local-language content, intermediary capacity and long-term monitoring, rather than platform scale alone.

Partnerships need to operate across **scales**. Local SMEs, extension providers, cooperatives, civil society organizations and regional platforms can adapt tools to local languages, farming systems, business models and trust relationships.[76] Community-based organizations, women's groups, farmer organizations



A woman in the Chitetezo Co-operative Federation uses a laptop to plan farmer trainings. Photo: Accelerating the Impact of CGIAR Climate Research for Africa (AICCRA) / Kelvin Trautman, KANDS Collective, CC BY-NC-SA 2.0

Regeneration of bean and tropical forage seeds at the Alliance of Bioversity and CIAT in Columbia. Photo: ©2021 CIAT/Juan Pablo Marin García, CC BY-NC-SA 2.0

and Indigenous or local knowledge institutions are essential for legitimacy and accountability. Their role should not be limited to consultation. They should help define problems, test solutions, identify risks, validate recommendations, and decide how benefits and responsibilities are shared.[83]

By 2050, partnerships for digital agriculture should operate as multilevel ecosystems of shared authority. CGIAR and public institutions would steward evidence and safeguards; SMEs and cooperatives would provide locally adapted services; and community-based organizations would shape design, validation and accountability. Success should be measured not only by scale or adoption, but by whether partnerships strengthen trust, protect data rights, expand women's agency and keep digital innovation accountable to food security and social inclusion goals. These indicators apply across research, policy, investment and implementation partnerships. Core indicators should include gender-disaggregated access, sustained use, control over devices and accounts, ability to act on information, participation in co-design, access to complementary services, representation in governance, and functioning mechanisms for privacy, transparency, redress and accountability.

Digital inclusion will matter more by 2050 because digital systems will increasingly mediate how people access information, finance, markets, public services, advisory systems and governance. The central question is not whether more women and socially excluded groups can be connected to digital tools. It is whether these systems expand their ability to decide, act, refuse, adapt and shape the technologies that affect their livelihoods.

The evidence shows that access and usability remain necessary, but they are not enough. Connectivity, devices, training and interface design can improve reach, yet benefits depend on whether users have control over accounts, privacy, data, resources, social support and decision-making power. Effective pathways, therefore, combine infrastructure, affordability, skills, trusted intermediaries, bundled services, collective institutions and responsible governance.

The 2050 agenda must also be realistic about evidence. Many interventions show reach and short-term benefits, but fewer demonstrate sustained empowerment or transformation. Future research, policy and investment should, therefore, focus on agency, accountability and institutional change.

An agency-centered digital future is possible, but it will not emerge automatically from technological progress. It requires digital systems that are materially accessible, socially usable and politically answerable. It also requires women, youth, Indigenous communities, persons with disabilities, migrants and other socially excluded groups to be treated not only as users, but as knowledge holders, data rights holders, co-designers and decision-makers in **FLWS transformation**.

# Chapter 4 · References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