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# Digital Skills, Innovation and Women's Participation in Emerging Economies

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**Abstract**
Digital transformation is reshaping economic participation in emerging economies, yet women's inclusion in technology sectors remains constrained by unequal access to skills, resources, and decision-making spaces. This study examines how digital skills acquisition interacts with innovation ecosystems to influence women's participation, empowerment, leadership, and innovation outcomes in Tanzania's technology sector. It investigates how digital competencies translate into economic opportunities, governance participation, and contributions to sustainable development. Using a qualitative design, the study combined semi-structured interviews, focus group discussions, and stakeholder consultations with 120 women engaged in technology initiatives across urban and peri-urban Tanzania. The study analysed data through thematic interpretation and contextual analysis to examine relationships between skills development, institutional support, innovation platforms, and outcomes. Findings reveal that digital training alone does not guarantee inclusion: although 68% of participants completed formal digital training, only 32% attained decision-making roles, demonstrating persistent institutional and socio-cultural barriers. However, women participating in incubator-supported innovations saw a 24% average income increase, compared with 9% among independent innovators, suggesting that mentorship, networks, and platforms convert skills into entrepreneurship and economic empowerment. Women-led digital solutions, including climate-smart agricultural applications, digital platforms for environmental monitoring, and technology-enabled sustainable resource management initiatives, illustrate how inclusive innovation contributes to climate action. Greater participation also strengthens governance by enabling women to influence technology policies, accountability processes, and community decision-making. The study concludes that gender-responsive digital strategies must integrate skills development with supportive ecosystems, leadership pathways, and inclusive innovation policies. The study recommends coordinated investments to close structural gaps and advance sustainable, equality-driven digital transformation.

## 1.0 Introduction

The accelerating diffusion of digital technologies has transformed patterns of economic participation across emerging economies by reshaping labour markets, entrepreneurial ecosystems, knowledge production, and pathways for social mobility. Digital transformation is increasingly recognised as a critical driver of sustainable development because it creates opportunities for innovation, financial inclusion, and access to new forms of economic participation. However, the benefits of technological change remain unevenly distributed, with gender inequalities continuing to shape who acquires digital capabilities, participates in innovation ecosystems, and holds positions of influence within technology-driven sectors. Thus, digital inclusion cannot be understood merely as access to devices or connectivity; it requires meaningful engagement through skills development, institutional support, and opportunities to translate knowledge into economic and social agency (Kamberidou and Pascall, 2020). In emerging economies, this distinction matters because digital transformation occurs alongside persistent structural inequalities, including unequal education opportunities, limited access to innovation networks, and gendered labour market constraints.

Recent debates increasingly frame digital skills as a strategic capability that enables individuals to move beyond technology consumption toward innovation, entrepreneurship, and leadership. Digital competencies provide women with technical abilities, but their transformative value emerges when combined with networks, mentorship, financial resources, and supportive institutions. Through these mechanisms, digital skills can increase entrepreneurial autonomy, strengthen confidence, expand professional networks, and enhance women's ability to participate in decision-making spaces within technology ecosystems (Mesa and Jacinto, 2021). However, existing research also demonstrates that skills acquisition alone does not automatically overcome structural exclusion. Women may complete digital training yet remain underrepresented in leadership positions because organisational cultures, social expectations, and institutional arrangements continue to shape access to opportunities (Quraishi et al., 2024). This tension highlights the need to examine digital empowerment not only as an individual capability but also as an outcome influenced by wider innovation systems.

Within Tanzania, digital transformation has expanded through increased mobile connectivity, fintech development, technology hubs, and entrepreneurship programmes. These developments have created new spaces for innovation and economic participation, yet access to these opportunities remains uneven. Women's participation in technology initiatives has increased. However, many women remain concentrated in lower-level technical roles, informal digital enterprises, or short-term project-based activities rather than strategic leadership positions. Such patterns reflect broader institutional and socio-cultural barriers affecting education pathways, employment opportunities, access to capital, and representation in innovation decision-making (Quraishi et al., 2024). Therefore, understanding women's participation in technology requires moving beyond participation rates to examine how digital capabilities translate into economic empowerment, leadership visibility, and influence within innovation ecosystems.

Innovation ecosystems provide an important analytical lens for understanding these processes because they demonstrate that technological participation is shaped by relationships among

entrepreneurs, institutions, policy actors, investors, and knowledge networks. While innovation ecosystems are often presented as mechanisms for economic empowerment, their benefits depend on whether institutional arrangements support inclusive participation (Founou et al., 2023). Mets and Vettik-Leemet (2024) argue that policy environments, organisational structures, and cultural expectations shape innovation outcomes and can either enable or restrict participation. Consequently, women's engagement in technology sectors should not be viewed only through employment outcomes but also through their ability to influence technological priorities, participate in governance processes, and contribute to accountability within digital spaces (Mtengwa, Muchenje and Maregere, 2024). From an empowerment perspective, participation becomes meaningful when individuals access resources, build collective capacity, and influence decisions affecting their communities and institutions (Zimmerman, 2000). In this sense, women's participation in technology contributes to governance by increasing representation in digital decision-making, strengthening accountability of innovation actors, and ensuring that technological solutions respond to diverse social needs.

The relationship between gender, digital innovation, and sustainable development is further complicated by technology's growing role in addressing climate challenges. Digital transformation increasingly supports climate adaptation through applications such as digital agricultural advisory platforms, environmental monitoring systems, climate information services, and energy-efficiency technologies. In Tanzania, women-led digital initiatives have shown potential through innovations focused on agricultural data collection, mobile platforms that connect farmers with climate information, digital tools for monitoring environmental conditions, and technology-based solutions that improve resource efficiency. These initiatives show how women's technological participation can extend beyond economic empowerment by strengthening community resilience and supporting locally appropriate climate solutions. However, research on women's role as digital innovators in climate action remains limited, particularly in emerging economy contexts where gender, technology, and environmental vulnerability intersect.

Despite increasing policy attention towards digital inclusion and gender equality, important empirical and conceptual gaps remain. Previous studies frequently examine digital access, economic empowerment, governance, and sustainability as separate dimensions rather than interconnected processes. Existing literature explains the importance of digital skills and innovation ecosystems but provides limited understanding of how women in Tanzania transform digital competencies into sustained participation, leadership influence, entrepreneurial outcomes, and climate-oriented innovation. This study addresses this gap by examining the relationship between digital skills acquisition and women's engagement within technology ecosystems, while analysing the institutional conditions that determine whether skills translate into meaningful empowerment.

The study examines how digital skills development and innovation ecosystems influence women's participation in Tanzania's technology sector. Specifically, it seeks to:

(i) Assess how digital skills acquisition influences women's economic empowerment, measured through income changes, entrepreneurial autonomy, employment stability, and

perceived financial independence within technology and innovation ecosystems in Tanzania.

(ii) Analyse how digital transformation initiatives contribute to inclusion and reduce barriers affecting women's participation in technology sectors.

(iii) Evaluate how women's engagement in digital innovation contributes to governance, leadership representation, and accountability within emerging technology spaces.

(iv) Explore how women-led digital innovations contribute to climate action and sustainability-oriented solutions, particularly within agricultural monitoring, environmental data management, and energy-efficiency initiatives.

By focusing on women engaged in technology initiatives in Tanzania, this study extends existing debates by linking digital capability development with institutional inclusion, governance participation, and sustainable innovation outcomes. It argues that digital transformation becomes a pathway for equality-driven development only when skills development is combined with supportive innovation ecosystems, gender-responsive policies, and opportunities for women to exercise leadership. The study therefore contributes to broader discussions on how emerging economies can use digital transformation to advance economic empowerment, accountable governance, and climate-resilient development.

## 2. Methodology

This study adopts a qualitative research approach to examine how digital skills acquisition, innovation ecosystems, and structural conditions influence women's participation in technology sectors in an emerging-economy context, focusing specifically on women engaged in technology initiatives in Tanzania. A qualitative approach was selected because the study seeks to understand how digital competencies translate into meaningful participation, economic empowerment, leadership visibility, and innovation outcomes. Rather than measuring digital inclusion only through access indicators, the methodology explores how women experience, interpret, and negotiate opportunities and constraints within technology ecosystems.

The methodology's conceptual foundation draws on empowerment perspectives, which emphasise that agency develops through access to resources, social networks, and opportunities to influence decisions (Zimmerman, 2000). Within this framework, digital skills are understood not simply as technical abilities but as enabling resources that can expand women's entrepreneurial capacity, professional networks, confidence, and participation in decision-making processes. The study also draws on innovation diffusion perspectives, recognising that the adoption and impact of digital technologies are shaped by social, institutional, and contextual factors. This theoretical positioning enables analysis of why digital skills may generate different outcomes among women depending on access to mentorship, innovation platforms, organisational support, and governance structures.

### 2.1 Study Design and Research Context

The study employed a comparative qualitative case study design involving selected technology and innovation ecosystems across Tanzania. The design was chosen because women's participation in digital economies is shaped by geographical, institutional, and socio-economic

contexts that quantitative indicators alone cannot fully capture. A comparative approach enabled examination of similarities and differences between urban and peri-urban innovation environments, highlighting how variations in infrastructure, institutional support, connectivity, and access to innovation networks influence women's opportunities.

The study was conducted in selected urban technology hubs and peri-urban communities where digital initiatives, entrepreneurship programmes, innovation incubators, and technical training activities are increasingly developing. Urban settings provided insight into environments characterised by greater concentration of technology companies, coding academies, startup incubators, digital entrepreneurship programmes, and professional networks. In contrast, peri-urban settings allowed investigation of challenges related to limited connectivity, fewer mentorship opportunities, restricted access to investment networks, and weaker links to formal technology employment pathways.

The comparative design incorporated both horizontal and vertical dimensions of analysis. The horizontal comparison examined differences between geographical contexts, particularly urban and peri-urban environments. The vertical dimension explored variations in women's influence across levels of engagement, including individual skill development, entrepreneurial activity, organisational participation, and involvement in innovation governance processes. This approach extends previous research that often examines digital inclusion as an issue of access alone by analysing how digital capabilities are converted into participation, empowerment, leadership, and accountability outcomes within specific institutional environments.

2.2 Study Population and Sampling Strategy

The study population consisted of women actively involved in technology-related initiatives in Tanzania, including software developers, digital entrepreneurs, participants in technical training programmes, innovation hub members, technology startup founders, community-based digital innovators, innovation hub coordinators, and relevant policy stakeholders. These groups were selected because they represent different stages of engagement within technology ecosystems, from skills acquisition and employment to entrepreneurship, leadership, and innovation decision-making.

A purposive sampling strategy was initially applied to identify participants with direct experience of women-in-tech initiatives and digital innovation activities. This ensured that participants possessed relevant knowledge of digital skills development, technology participation, and institutional support mechanisms. To improve diversity and reduce overrepresentation of particular groups, stratified sampling was subsequently applied across professional categories, years of experience, geographical location, and forms of technological engagement.

The final sample comprised 120 women participating in technology initiatives across urban and peri-urban Tanzania. This sample size was considered appropriate for qualitative inquiry because it enabled sufficient variation in experiences while allowing detailed exploration of individual and collective perspectives. Participants represented different pathways into technology, including formal employment, entrepreneurship, training programmes, and innovation projects. This diversity was important for analysing how digital skills translate into different forms of

empowerment, including income generation, entrepreneurial autonomy, leadership opportunities, and participation in technology governance.

### 2.3 Data Collection Procedures and Research Instruments

Data were collected through semi-structured interviews, focus group discussions, and stakeholder consultations. Semi-structured interviews were selected because they allowed participants to explain their experiences while ensuring consistency across key themes. Focus group discussions were used to capture shared experiences, collective challenges, and perceptions regarding women's participation within technology communities. Stakeholder consultations provided additional perspectives on institutional support systems, policy implementation, and innovation ecosystem development.

Interview and discussion guides were developed from existing literature on digital inclusion, gender empowerment, innovation ecosystems, governance participation, and sustainable development. Questions focused on five major areas: (1) access to digital skills training and technology resources; (2) pathways through which digital competencies influenced employment, entrepreneurship, and economic independence; (3) experiences of leadership, decision-making, and participation within technology spaces; (4) institutional and socio-cultural barriers affecting inclusion; and (5) contributions of women-led digital innovations to sustainability and climate action.

The study specifically explored how digital skills enabled women to move from technology users to technology creators and decision-makers. Participants were asked how technical knowledge influenced their ability to develop digital products, access markets, establish enterprises, collaborate through innovation networks, and contribute to community solutions. The study also examined climate-related innovation experiences, including digital agricultural monitoring tools. These mobile platforms provide farmers with climate information, environmental data collection systems, and technology-enabled approaches to improving energy efficiency and resource management.

All interviews and discussions were audio-recorded with participant consent, transcribed verbatim, and anonymised. The field notes documented contextual observations, emerging patterns, and researcher reflections throughout the data collection process.

### 2.4 Data Analysis Procedures

The study employed thematic analysis following the six-phase framework developed by Braun and Clarke (2006). The analytical process involved familiarising the data, generating initial codes, developing candidate themes, reviewing and refining themes, defining thematic categories, and interpreting findings.

Coding was conducted systematically to identify patterns relating to digital skills acquisition, empowerment pathways, innovation participation, leadership experiences, governance engagement, and sustainability contributions. The analysis examined not only whether women possessed digital skills but also how these skills produced outcomes. For example, the analysis

examined digital competencies in relation to increased entrepreneurial activity, improved access to professional networks, participation in innovation projects, greater visibility in technology communities, and involvement in decision-making processes.

The analysis also explored the relationship between women's technology participation and governance outcomes. The analysis examined women's involvement in digital innovation as a mechanism for bringing diverse perspectives into technology design, policy discussions, and accountability processes. By participating in technology development and innovation networks, women can influence whose needs are prioritised, how digital solutions are implemented, and how technology initiatives respond to community challenges.

A comparative thematic approach identified differences between urban and peri-urban experiences and examined how institutional conditions shaped outcomes. Themes were continuously compared across participant groups to identify common experiences, contrasting perspectives, and contextual influences.

### 2.5 Trustworthiness, Validity, and Reliability

Several strategies were applied to strengthen the credibility and trustworthiness of the findings. First, the study used multiple data sources, including interviews, focus groups, and stakeholder consultations, to achieve methodological triangulation. This allowed comparison of individual experiences with broader institutional perspectives.

Second, the researcher conducted member checking selectively by sharing summaries of interpreted findings with participants to confirm whether themes accurately reflected their experiences. Third, the researcher maintained detailed documentation of sampling decisions, coding procedures, and analytical interpretations to support transparency and dependability.

The researcher also engaged in reflexive practice by documenting assumptions and potential influences throughout the research process. This was particularly important given the gendered nature of the study and the possibility that power relationships between researchers and participants could influence responses. These procedures strengthened the reliability and credibility of the analysis while ensuring that participants' experiences were represented accurately.

### 2.6 Ethical Considerations

Ethical approval was obtained from the relevant institutional review boards before the study began. Participants received detailed information about the study objectives, procedures, potential risks, and their rights as research participants. Participation was voluntary, and we obtained informed consent before conducting interviews and discussions.

Confidentiality and anonymity were prioritised by removing identifying information and securely managing research data. Participants were informed of their right to withdraw at any stage without negative consequences. Given the professional and gendered dimensions of the research, additional attention was paid to creating safe interview environments where participants could discuss experiences of exclusion, workplace challenges, and institutional barriers.

Interview scheduling accommodated participants' professional and personal responsibilities, particularly because many women involved in technology initiatives balance employment, entrepreneurship, and family obligations. The study maintained an ethical commitment to respectful representation, ensuring that participants' experiences informed the analysis without exposing them to professional or social risks.

The methodological design enables a comprehensive examination of how digital skills interact with innovation ecosystems to shape women's participation in Tanzania's technology sector. By combining comparative case analysis, purposive and stratified sampling, qualitative inquiry, thematic interpretation, and rigorous trustworthiness procedures, the study provides evidence on how digital transformation can contribute to economic empowerment, inclusive governance, leadership development, and climate-responsive innovation within emerging economies.

## 3. Results and Discussion

The findings demonstrate that the interaction between digital capabilities, institutional environments, innovation networks, and socio-cultural conditions shapes women's participation in Tanzania's technology ecosystems. Consistent with the study objectives, the results show that digital skills are an important entry point into technology participation. However, their ability to generate empowerment, leadership, and innovation outcomes depends on whether women can access supportive ecosystems that convert skills into opportunities. The findings therefore challenge a skills-only assumption of digital inclusion by demonstrating that mentorship, professional networks, institutional recognition, and access to decision-making spaces must accompany technical competencies.

The quantitative results indicate that 68% of the 120 women participants had completed at least one formal digital skills training programme. However, only 32% held decision-making positions within their organisations or innovation initiatives. This gap between training participation and leadership representation suggests that acquiring digital skills improves women's readiness to participate in technology spaces but does not automatically overcome institutional barriers that influence authority, recognition, and career progression. This finding supports Rikala et al. (2024), who argue that digital participation is shaped not only by individual competencies but also by organisational cultures, social expectations, and unequal access to professional networks. Thus, the results contribute to the study's first and third objectives by demonstrating that empowerment involves both capability development and the ability to exercise influence within technology ecosystems.

### 3.1 Digital Skills Acquisition, Participation, and Access to Opportunity

The findings indicate that digital skills enable women's entry into technology ecosystems; however, their impact varies with access to innovation channels and supportive environments. Participants identified foundational digital literacy, including computer skills, online communication, coding, software development, and digital entrepreneurship competencies, as essential pathways for accessing technology-related employment and innovation opportunities. However, the analysis revealed that progression from basic competence to meaningful

participation depended heavily on access to advanced training, mentorship, and professional networks.

One participant explained:

*"I completed coding classes, but the real opportunities are in Dar es Salaam. Here, even with skills, there are few spaces for innovation projects."*

This experience illustrates the difference between having digital capability and having the institutional conditions needed to apply it. The finding aligns with diffusion of innovation theory, which argues that technology adoption and innovation participation are influenced by social systems, access to communication channels, and proximity to innovation actors rather than individual ability alone (Rogers, 1983). In this study, urban participants benefited from greater exposure to innovation hubs, coding communities, investors, and professional networks. In contrast, peri-urban participants faced constraints related to connectivity, limited mentorship, and fewer opportunities for collaboration.

Therefore, digital skills contributed to participation through three interconnected mechanisms: improving technical confidence, increasing access to economic networks, and enabling women to contribute to technology-based solutions. However, without institutional pathways connecting skills to employment, entrepreneurship, and leadership opportunities, digital training risks producing capability without meaningful inclusion.

3.2 Digital Innovation Participation and Economic Empowerment

The second objective examined how digital transformation initiatives influence women's economic empowerment. The findings show that participation in innovation ecosystems generated stronger economic outcomes when digital skills were combined with mentorship, incubation support, and entrepreneurial networks. Women involved in incubator-supported initiatives reported an average income increase of 24%, compared with 9% among women operating independently. These differences suggest that innovation ecosystems translate digital knowledge into economic value by providing access to markets, funding opportunities, business development support, and peer learning.

The relationship between skills and empowerment was particularly evident in participants' descriptions of increased confidence, entrepreneurial autonomy, and professional recognition.

One participant stated:

*"Being in a tech hub changed how I see myself. I can pitch ideas now, and people listen."*

This account demonstrates that empowerment occurs not only through financial outcomes but also through increased self-efficacy and social recognition. Digital skills enabled women to develop products, communicate ideas, access entrepreneurial opportunities, and participate in innovation communities. However, these benefits were unevenly distributed. Peri-urban participants reported challenges, including unreliable internet access, limited exposure to investors, and social expectations that discouraged women from pursuing technology leadership.

These findings reinforce innovation ecosystem perspectives, which emphasise that entrepreneurial success depends on relationships among skills, institutions, resources, and networks rather than individual capacity alone (Founou et al., 2023). The results extend this perspective by showing that women's digital empowerment in Tanzania is relational: skills create possibilities, but ecosystems determine whether those possibilities become sustainable economic outcomes.

3.3 Leadership, Governance Participation, and Accountability Outcomes

The third objective examined how women's participation in technology contributes to leadership, governance, and accountability. Findings reveal that women who combined technical expertise with communication, project management, and leadership skills were more likely to participate in strategic decision-making roles. However, the limited representation of women in leadership positions, reflected in the finding that only 32% held decision-making roles, indicates that institutional barriers continue to restrict progression beyond technical participation.

Participants highlighted challenges related to recognition and legitimacy. One participant explained:

*"Even when I lead projects, people assume decisions are temporary or that I am less capable than male colleagues."*

This finding demonstrates that both structural and perceptual dimensions influence leadership participation. Women may possess technical expertise but still encounter assumptions that limit their authority and influence. Consistent with empowerment theory, meaningful participation requires more than access to resources; it requires the ability to influence decisions and shape institutional outcomes (Zimmerman, 2000).

The findings also clarify the link between women's participation in technology and governance/accountability. When women contribute to technology design, innovation management, and digital policy discussions, they bring diverse perspectives to decision-making. Their involvement strengthens accountability by improving responsiveness to community needs, particularly in contexts where digital solutions affect livelihoods, access to services, and economic opportunities. Therefore, women's representation in technology ecosystems is not only a question of equality but also a governance issue, as inclusive participation shapes whose priorities are reflected in technological development.

3.4 Women-Led Digital Innovation and Climate Action

The findings also reveal an important connection between women's digital participation and climate-oriented innovation. Participants described technology initiatives that applied digital tools to address environmental and livelihood challenges, demonstrating that women's engagement in technology extends beyond employment outcomes.

Examples included mobile agricultural monitoring platforms that use digital information to support farmers' decision-making, community-based environmental data platforms that track local

ecological changes, and energy-efficiency technologies designed to improve resource management. One participant described developing:

*"A mobile app to track crop health using satellite data. Farmers trust us because we understand their challenges."*

Such innovations demonstrate how digital skills enable women to become producers of knowledge and solutions rather than only consumers of technology. By combining technical expertise with local understanding, women innovators contribute to climate adaptation strategies that respond to community-specific vulnerabilities.

These findings support broader sustainability debates by showing that digital inclusion can create pathways connecting gender equality, innovation, and environmental resilience. However, the limited documentation of women-led climate technologies suggests an ongoing research and policy gap in understanding how women's digital entrepreneurship contributes to sustainable development outcomes.

3.5 Integrated Interpretation of Findings

Overall, the findings show that digital skills are necessary but insufficient to achieve meaningful inclusion in technology ecosystems. The results indicate that digital competencies create opportunities for participation by improving women's ability to access information, develop innovations, establish enterprises, and engage with professional networks. However, empowerment outcomes emerge only when mentorship, institutional recognition, infrastructure, and inclusive innovation policies support skills.

The relationship between digital skills and outcomes can therefore be understood as a progression: digital training provides capability; innovation networks convert capability into participation; institutional support enables economic empowerment and leadership; and inclusive governance structures allow women to influence technology development. The study's quantitative and qualitative findings collectively show that participation must be understood as both measurable and experiential, involving income improvement, decision-making authority, confidence, recognition, and social impact.

The Tanzanian case demonstrates that advancing women's participation in technology requires integrated interventions that address skills development alongside structural barriers. Policies focused only on training may increase the number of digitally skilled women without significantly changing leadership representation or their influence on innovation. Instead, sustainable inclusion requires coordinated investment in mentorship, infrastructure, entrepreneurship support, gender-responsive innovation policies, and mechanisms that ensure women participate in technology governance and climate-oriented innovation.

## 4. Conclusion and Recommendations

This study examined how digital skills acquisition, innovation ecosystems, and institutional conditions shape women's participation in Tanzania's technology sector. The findings

demonstrate that digital skills provide an essential foundation for participation by enabling women to access information, develop technical capabilities, engage in entrepreneurial activities, and contribute to digital innovation. However, the study concludes that skills alone do not automatically produce empowerment or leadership outcomes. Consistent with empowerment theory (Zimmerman, 2000), digital capabilities become transformative when women can access supportive networks, innovation platforms, institutional recognition, and decision-making opportunities.

Regarding the first objective, the study found that digital skills contribute to economic empowerment by improving women's ability to participate in technology-based entrepreneurship, access employment opportunities, and develop innovative solutions. However, translating skills into economic outcomes depends on complementary resources such as mentorship, incubation support, and market connections. This suggests that empowerment emerges from the interaction between individual capability and ecosystem support rather than from training alone.

Regarding the second objective, the findings show that digital transformation initiatives expand opportunities for women's participation in technology but continue to reproduce inequalities, as infrastructure, access to funding, and institutional support remain uneven. The difference between skills acquisition and leadership representation demonstrates that inclusion requires addressing structural barriers alongside expanding digital literacy.

The third objective focused on governance, leadership, and accountability. The study concludes that women's participation in technology contributes to governance outcomes by increasing representation in digital decision-making processes. When women participate as developers, entrepreneurs, and innovation leaders, they influence which problems are prioritised, how technologies are designed, and whether digital solutions respond to diverse community needs. Therefore, women's participation strengthens accountability by ensuring that technology ecosystems incorporate broader perspectives and remain responsive to social realities.

The fourth objective examined women-led digital innovation and climate action. The study demonstrates that digital competencies enable women to contribute to sustainability-oriented solutions, including mobile agricultural monitoring platforms, environmental data collection tools, and energy-efficiency technologies. These examples show that women's participation in technology extends beyond economic advancement by supporting locally grounded responses to climate challenges.

The study concludes that meaningful digital inclusion requires a shift from a skills-centred approach towards an ecosystem-based approach. Digital skills create opportunities for participation, but mentorship, institutional support, infrastructure, and inclusive governance mechanisms determine whether those opportunities result in empowerment, leadership, and sustainable innovation.

### 4.1 Limitations

This study has several limitations. First, although the qualitative sample captured diverse experiences across selected Tanzanian innovation ecosystems, the findings cannot be statistically

generalised to all women participating in technology sectors nationally. Second, the study relied partly on participant accounts of empowerment, income changes, and professional experiences, which individual perceptions and recall may influence. Third, the focus on selected urban and peri-urban locations limits understanding of women's experiences in more remote rural communities where digital infrastructure and innovation ecosystems may differ significantly.

Future studies should adopt longitudinal designs to examine how women's participation develops over time and should include broader geographical coverage to compare urban, peri-urban, and rural technology pathways. Further research should also investigate how specific interventions, such as mentorship programmes, incubation models, and gender-responsive innovation policies, influence long-term empowerment and leadership outcomes.

### 4.2 Recommendations

Based on the findings, several recommendations are proposed:

(i) **Integrate digital skills development with mentorship and professional networks:** Digital training programmes should move beyond technical instruction by connecting women with mentors, innovation communities, investors, and industry professionals. These networks are necessary to convert skills into entrepreneurship, employment advancement, and leadership opportunities.

(ii) **Strengthen institutional support for women-led innovation:** Government agencies, private sector actors, and innovation organisations should expand access to incubation support, seed funding opportunities, and technology infrastructure, particularly in peri-urban areas where participants reported fewer innovation pathways. Support mechanisms should also recognise women's leadership contributions within technology ecosystems.

(iii) **Develop inclusive innovation platforms beyond major urban centres:** Innovation hubs and accelerators should create flexible participation models, including virtual mentorship, community-based programmes, and decentralised innovation activities. This would reduce geographical inequalities and enable women outside major technology centres to access networks and opportunities.

(iv) **Embed leadership, governance, and advocacy skills within digital training programmes:** Digital literacy initiatives should incorporate communication, project management, entrepreneurship, and governance competencies. These skills can strengthen women's confidence and capacity to participate in decision-making processes and influence technology development priorities.

(v) **Promote women-led digital solutions for climate resilience:** Policies supporting digital innovation should encourage women entrepreneurs developing sustainability-focused technologies, including digital agricultural services, environmental monitoring systems, and resource-efficiency solutions. Supporting these initiatives can strengthen the connection between gender equality, technological innovation, and climate adaptation.

(vi) **Establish continuous monitoring and evaluation systems:** Institutions implementing women-in-tech programmes should track outcomes beyond training completion, including

employment progression, entrepreneurship development, leadership participation, and contributions to innovation and sustainability goals.

Advancing women's participation in technology ecosystems requires recognising that digital skills are a foundation, not the final outcome. When combined with supportive innovation environments, institutional recognition, and leadership opportunities, digital capabilities can enable women to become active contributors to economic transformation, accountable governance, and sustainable development in emerging economies.

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