



Grassroots and gendered innovation: A literature review towards feminist innovation in AI

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Introduction: innovation, technology, and gender

This paper presents a literature review on grassroots innovation, focusing on the innovation process, main challenges, and technology adoption for empowering women from selected articles from the Scopus database from 2016 to March 2021. The information-gathering included the localization of papers related to keywords such as grassroots innovation, gender, women empowerment, ICT, internet and artificial intelligence analyzing the contents and creating a perspective on the subject covered and the methodologies used. There are different types of innovation. Incremental innovation improves existing technologies in given markets; disruptive innovation applies new technologies to existing markets; architectural innovation moves technologies from one market to another; radical innovation is a step toward creating new industries and technologies, and frugal innovation refers to efficiency, doing more with fewer resources. All of them are necessary to create new developments and new ways to navigate the future. Sometimes some minor adjustments can create significant changes, for example visualizing gender norms. These concepts can be used to describe new technologies and discoveries in several fields of knowledge.

Grassroots innovation is rapidly gaining research attention because of its crucial role in entrepreneurship development. The main focus of grassroots women has been the policies to reduce gender-based inequalities such as the risk of climate change, vulnerabilities, poverty alleviation, building resilience, and a culture of political participation in rural areas. Many practices have been documented around the world as an effort to combat inequalities and create better conditions for women. These efforts, experiments, and implementations need to be examined from the perspective of the voices of grassroots women themselves, as well as the technology that they inspire.

The role of social innovation will be increasingly essential and imperative given the market forces and jobless future of automation. Gupta et al. (2017) point at the new opportunities presented by social innovation and the new economy's skills, and the necessity to address wicked problems. They posit through different authors a socio-ecological system that can recognize and reward innovation and be helpful as a hurdle for external shocks and emergent challenges.

Other enthusiasts of grassroots innovation like Smith and Stirling (2018) present the relevance of promoting this kind of innovation to enhance democracy and support social justice, environmental resilience and create empowering sociotechnical configurations that interests around mainstream innovation systems might otherwise suppress. This kind of innovation can increase social diversity levels by working at changes in culture, infrastructure, training, investment, and openness.

This research was catalogued in four main sections. 1) Grassroots innovation which includes a background and conceptualization framework on grassroots innovation. 2) Gendered innovation where we discuss how gender perspectives should be used to frame research and technological development. 3) The main section where we include the main findings and insights from the literature review, distinguishing national and local efforts, systemic biases and intersectional inequalities; best practices and expected outcomes and finally documented cases and data sharing that are worth mentioning. 4) We make final remarks from grassroots innovation and empowerment technologies for the future towards feminist innovation in AI.¹

¹ The papers analyzed for this literature review were retrieved from the Scopus database using the following search strings: "innovation process" AND tech AND women; "innovation process" AND tech AND gender; "innovation process" AND Gender, empower* AND women AND grassroots, innovation AND women AND grassroots; "open innovation" AND gender; grassroots AND women; grassroots AND ICT AND women; internet AND "social innovation" AND women.

Grassroots innovation

Gupta (2020), one of the most cited researchers of grassroots innovation (GRI), proposes a conceptual framework to understand GRI's factors and characteristics. He discusses the differences between GRI and innovation *at the grassroots* or *for the grassroots*.

Grassroots innovation comes directly from the community and offers inclusive, sustainable, and affordable problem-solving techniques based on indigenous knowledge and skills. The GRI can include expertise from the outside, engaging in a project, and providing impetus for collaborative movements. The promotion of innovation at grassroots communities contributes to societal and environmental development, adding value and creating knowledge. This kind of innovation can produce an outcome benefit of sustainable commercial (economic) and non-commercial (societal and environmental). Gupta (2020) includes six dimensions for GRI:

- Affordable cost. As the willingness of the market to pay given the limitations on cash and access to credit.
- Indigenous knowledge. Referring to the context-specific knowledge unique and given community, culture, or society, transmitted from one generation to another².
- Informal innovation. Used to address community-specific problems and come from local social capital and lack of support from formal public or private entities, they usually do not develop networks because of the separation from formal education and systems.
- Sustainability. Economic development in harmony with social and environmental values.
- Local fit. Local resources, local socio-economic environment, and local needs.
- Adaptability. Refers to the concept of being flexible. To fulfill different functions, the product might be adapted and change.

For Gupta (2019), innovation at the grassroots and for the grassroots have other characteristics. The first one is delivered by NGOs, corporations, governmental agencies, or individuals who unfold innovation at the community level using the social capital of the whole community, looking for sustainability and improving the quality of life of the community.³ The second one, innovation for the grassroots, focuses on socio-economic development with frugal innovation and reverse innovation, specifically with a plan for increasing the consumption in emerging markets.

Furthermore, other authors might not be precise in separating GRI from these different two types described by Gupta, and there are mixed concepts that can generate confusion about the nature and source of the innovation at the grassroots level. This problem is discussed by Pansera and Owen (2018) that frame grassroots innovation as inclusive innovation in the case of Indian policies. Where this term is used to present grassroots framing (emphasizing social and political empowerment, rooted in community self-sufficiency, autonomy, and traditional belief systems) and also the framework of market-based and readiness participation, they point out that this kind of innovation is transforming rural social practices (including the organization of space and time, the meaning of production and the role of women), introducing the potential for market dependency.

² The World Intellectual Property Organization refers to it as traditional knowledge, or a pool of ideas, practices, skills, and technical expertise, passed on from generation to generation within a community.

³ For example, the internet access to information and knowledge such as Wikipedia content, open-source initiatives, global communities spawned on web forums and social media platforms. Leading users to freely share innovations without expecting private returns only to solve shared technical problems.

Gupta et al. (2017) debate the construction of an ecosystem of open innovation that can support grassroots innovation given the market failures and the institutional limitations to foster trust among different actors and other processes. Open innovation and trust could connect corporations with communities, practice inclusion in social movements, promote technological adaptability. The corporations need to be empowered to understand the decision heuristics followed by grassroots and community frugal innovators, just as communities need to be empowered to negotiate fairly and exchange relationships with corporations.

Vossenbergh (2018) studies the importance of frugal innovation to empower marginalized women in contexts where those innovations are more likely to reproduce or transform institutionalized gender-related constraints that structure how men and women can access resources and opportunities. More research on this kind of innovation is needed to evaluate the impact on gender barriers with a multidisciplinary approach.

Dana et al. (2021) propose a diagnostic tool for grassroots innovation projects in three main phases: 1) The inception, an analysis of the problem, idea creation, assessment of the contextual novelty, and potential utility. 2) Protective niche phase where a prototype is developed assessing the project (relative advantage, compatibility, complexity, trialability, and observability). 3) Open market phase to scale-up and project launch, including analysis on market forces such as customers, suppliers, distributors, direct competitors, products and substitution, and potential entrants. Finally, they call attention to the importance of local community involvement and socially inclusive approach for the effective deployment of grassroots innovations.

Duarte et al. (2020) analyze the impacts of innovative practices in the social enterprise with technology adoption, implementation of new products or services, and harnessing skills. The effects observed include encouraging inclusiveness among residents and non-residents, with approaches including hands-on training workshops, job and volunteering opportunities. They acknowledge the literature gaps on processes and determinants of innovation among social enterprises.

To understand the study of grassroots innovation, the multi-level perspective (MLP) is an approach for social transformations and sustainability. Geels (2019) explains transitions in systems (energy, transport, housing, agro-food systems) need alignments between technologies, policies, user patterns, infrastructure, and cultural discourses. The incremental and path-dependent innovation exists in systems because of lock-in mechanisms such as techno-economic, social, cognitive, institutional, and political. Radical innovations emerge in small niches throughout pioneering system outsiders' activities, and their degree of radicality consists of how much they deviate from existing systems.

One of the system transition research from Geels (2019) is grassroots innovation characterized by activists doing social innovation and using green technologies. Foreground moral values and collective aspirations to change social practices and ways of living. There are several challenges in applying MLP to grassroots innovation: 1) reliance on voluntary commitments of dedicated champions makes them vulnerable. 2) learning projects do not document their tacit knowledge and engage in informal learning, so local projects' context-specificity might not collect or articulate best practices. 3) Some grassroots innovations do not aspire to scale up and grow outside the local community. 4) They might face contextual challenges from legal and regulatory mismatches with the border regime. 5) Commitments to radical values complicate access to mainstream funding. 6) Diversity and inclusion on projects mainly because the participants in some projects are white or not representative of the wider community's demographics.

Table 2**Comparing the characteristics of market-based and grassroots innovations [74, p. 92]**

	Market-based innovations	Grassroots innovations
Context	Market economy	Social economy
Driving force	Profit: Schumpeterian rent	Social need; ideological
Niche protection	Market rules are different: tax and subsidies temporarily shelter novelty from full forces of the market	Values are different: alternative social and cultural expressions enabled within the niche
Organizational form	Firms	Voluntary associations, co-ops, informal community groups
Resource base	Income from commercial activity	Grant funding, voluntary input, mutual exchanges, limited commercial activity

Source: Geels (2019) based on the work of Seyfang (2007).

In the conceptualization framework, grassroots innovations are often related or presented as innovation for sustainability. Based on Seyfang and Lunghurst's (2013) concepts about sustainability transitions, technological innovations can diffuse and disrupt existing socio-technical systems through the successful scaling up of experimental niches. This contextual paper identifies the existing literature on innovation at the grassroots context and the importance of innovation processes to promote this kind of innovation, such as building networks and addressing external landscape pressures, especially at the country level.

Joshi and Yenneti (2020) include priority values, representative technological fields, dominant actors, principal drivers and incentives, funding and investment, and innovation sites as the characteristics of the mainstream grassroots approaches to innovation for sustainability. Furthermore, Joshi and Yenneti (2020) contextualize the practice of grassroots innovation for sustainability in different global contexts such as eco-villages, transition towns, low-carbon development, sustainable cohousing, alternative food networks, and community energy projects. Usually, grassroots innovation for sustainability is based on informal knowledge practices that represent an alternative epistemology to modern western science and technology. This kind of innovation supports local niche creation and new arrangements of social organization (community networks) and technological systems of change (energy communities).

Belda-Miquel et al. (2020) propose a framework for grassroots innovation and socio-technical transitions with a multilevel perspective. They conclude that this kind of innovation may be valuable for justices because they contribute to multi-dimensional human flourishing, improve public reasoning by creating counter-narratives, democratic spaces, and new capabilities for reasoning and mobilization. Furthermore, they create better structural conditions for more diversified, decentralized, and democratic systems that are not free from tensions and contradictions.

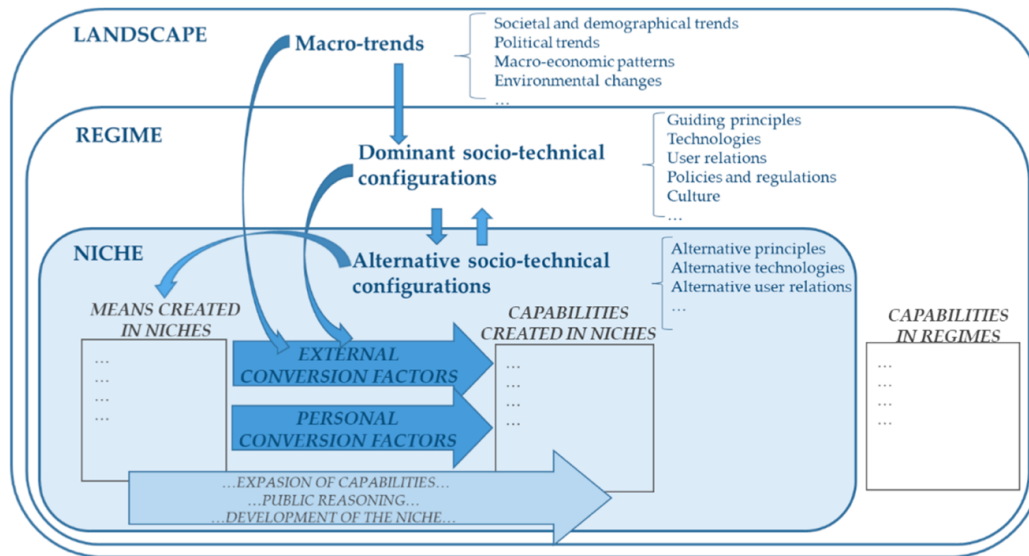


Figure 1. Theoretical framework for a normative analysis of grassroots innovations.

Belda-Miquel et al. (2020)

Sengers et al. (2019) provide an extensive literature review about how experiments are conceptualized on sustainability transitions using a methodology of identifying and synthesizing a review of the complex bodies of scientific research. Their findings state that an experiment is “an inclusive, practice-based and challenge-led initiative designed to promote system innovation through social learning under conditions of uncertainty and ambiguity.” They also include a typology of experiments such as niche, bounded socio-technical, transition, sustainability, grassroots, and new conceptualizations at the urban settings, each founded on normative orientations, theoretical foundation, analytical emphasis, and actor's coalitions.

Grassroots experimentation conceptualizes: 1) Normative orientation: inclusive green niche development for the broader transformation of mainstream society. 2) Theoretical foundations: social movement theory draws on niche-based approaches. 3) Analytical emphasis: sustainable consumption indicators (localization, reduction of ecological footprint, community building, collective action, new social infrastructure). 4) Main actors: civil society (especially local communities, ecological citizens as initiators).

Sengers et al. (2019) conclude about new approaches for the research agenda on the role of experimentation in fostering sustainability transitions.

1. The different forms of micro-politics, power, and agency in experimentation where actors might influence an experiment's design and outcome derived from access to resources and their respective relational position. Including exclusion and social justice (who decides who participates in the experimentation and the possible impacts for stakeholders not involved. Addressing such questions can also counter-balance the prominent focus in the experiments literature on consensus-oriented, learning-based, and shared visioning approaches to experimentation.
2. The polar opposite of zooming in on the micro-politics of one or a few experiments is to move beyond case-studies-based approaches. Create ways to zoom out with quantitative tools in databases to find patterns.

3. Geography of experimentation can be a start to expand the research agenda, especially in urban contexts. This is given that tensions between multiple systems create windows of opportunity for agents of change. Conversely, inter-system alignment can also be a source of additional complexity and path dependency, limiting radical change opportunities, including the influence of local and regional networks, infrastructures, resource endowments, and political agendas. These characteristics might influence experiments' success, making them case sensitive, also affecting the scales of experimentation, including transnational initiatives. For specific analysis of urban socio-technical transitions, Wolfram (2018) analyses Seoul's current policy efforts to create, diversify, and network social innovation in an urban neighborhood. How empowerment, proximity, and institutional thickness enable them to meet primary conditions and impact the formation pathways of urban grassroots such as urban empowerment capacities, embedded holistic innovation, novel community-oriented governance modes, and urban/regime interactions.
4. The role of business in experimentation where sectors considered niche are becoming industrial sectors such as cleantech opportunities. This pathway includes how firms' participation changes the nature of experiments focusing on the application of management perspectives, the role of social entrepreneurs, local communities, engaged citizens on the sustainability transitions creating new business models, and finding new ways of creating shared value.
5. The experimentation on specific societal functions instead of the welfare state or moving towards transforming those welfare states. Also, the experiments made on cities considering that national governments are still crucially important actors in enabling experimentation in cities (Oriented to the UK and the US).

Gendered innovation

There is extensive grassroots innovation literature expanding research scope, but gendered-oriented innovation is still limited, though increasing over the last few years. The use of feminist ethics and lens in scientific production has grown exponentially in the past few years to incorporate aspects of innovation towards women empowerment and growth. The work of Sarkki et al. (2021) includes feminist theories to the background of social innovation lead by women with case studies to propose a novel heuristic named reconstructive social innovation cycle that can assess implications of women-led social innovations for gender equity. Women-led social innovations do not adequately fit into the classic categorization of impacts as incremental, institutional or disruptive because of the performativity and the linkages of everyday practices to structural challenges for gender equity.

According to Sarkki et al. (2021), a reconstructive social innovation cycle can be defined as: “a cyclical process of engaging women via civil society initiatives that are reframing the existing state of affairs by changing or questioning marginalizing and discriminatory practices, institutions, and cognitive frames that are often perceived as normal.” Constructing on the adaptive cycle consists of four phases: 1) Growth and exploitation of the system. 2) Conservation as a maturity phase. 3) Collapse and release. 4) Reorganization where it enables itself to grow in a new configuration or systemic state. The transformations can be “back-loop,” a fast reorganization after the system’s collapse, and “front-loop” that consist of slow change or growth.

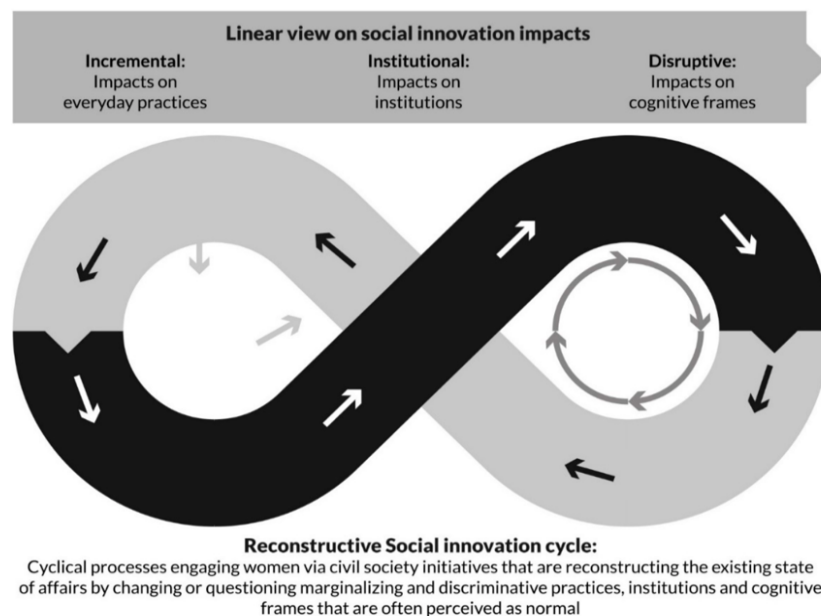


Figure 1. Two alternatives to consider impacts of social innovation. Firstly, according to a linear view, impacts grow in magnitude from Incremental via Institutional to Disruptive. Secondly, according to the proposed reconstructive social innovation cycle heuristic, the different levels of impacts are intertwined and inseparable. We propose that for understanding the impacts of women-led social innovations on gender equity the reconstructive social innovation cycle is more appropriate.

Source: Sarkki et al. (2021)

Poutanen and Kovalainen (2017) address the nature of gendered innovations in the new economy, tracking the contemporary shift from heavy industry to the game industry and how this has altered relationships between gender, identity, corporate culture, creative work, and the future of business.

They do a historical review on imbalances, disparities, and discrepancies in gender innovation in sectors such as household appliances in the entire 20th century, such as the introduction of the washing machine and the transformation on the gendered household division of work and time, and the eventual decline of household servants and temporary help. In the new knowledge economy, gender has become ingrained in many ways into the new jobs. While some labor types tend to be classified as 'women's work' or 'men's work,' there are also inequalities in patent applications with a lower percentage of female researchers, found mainly in the pharmaceutical industry and the technology sector. Thus, in constructing the new knowledge-based economy, we need to pursue new ways to assemblage the intersectionality's of gender, care work, and economy.

An interesting case on women empowerment is the research carried out by Khandekar et al. (2020) that constructed a protocol using a methodology known as Feminist Cooperative Inquiry (FCI). The FCI consisted of four phases: proposition, action, immersion, and reflection. These phases are aligned with ways of knowing: propositional and experiential knowledge and critical reflection. They used participatory research contributing to the process of building knowledge from the bottom - up. They conclude their journey by stating that "trust, inclusiveness, collectivity, transparency, authenticity and being non-judgmental, non-hierarchical emerged as core essential values in this research."

ICTs are the most changing tool in the modern world. The digital economy and the rise of artificial intelligence are game-changing in the global arena. Despite the evidence collected on the use of Information and Communication Technologies for Development (ICT4D) as a tool to empower society, the feminist perspective questions the nature of access and use of the technology where women are mere consumers of ICTs and play no role in development, resulting in the inappropriateness of new technologies and problems on structural use.

The gender gap in technology can be a huge inhibitor for development to be ignored and must be mandatory to create new ways to reduce these gaps in the future. Warnecke (2017) captures at least three forms of gender inequality derived from the technology gender gap. 1) Unequal access to knowledge, training, and employment, particularly decent work. 2) Unequal opportunities for self-discovery, social and professional relationship-building, and 3) unequal understanding of legal rights and modes for civic participation. To reduce these gender gaps, Warnecke proposes technological innovation paths such as spread knowledge, "know-how," and influence. This includes: Build a delivery network, form strategic partnerships, and grow the organization to encourage the development of new technologies. Nevertheless, it is essential to understand the possible barriers: awareness of options and utility, cost impacted by the monopolization of technology solutions and limited awareness of open-source software, cultural/social norms, education level/ basic literacy, employment opportunities, infrastructure coverage/quality, operator/agent trust, policies for gender equality and technical literacy/confidence.

Mackey and Petrucka (2021) provide a scoping review of literature for technology as a key to woman empowerment. They define the term women's empowerment as a process by which women reverse an oppressive condition, acquiring abilities to make autonomous and strategic life choices with their own priorities. Empowerment is achieved when a woman can have the resources, agency, and capabilities to execute those decisions. Their review concludes that empowerment has been inconsistently and poorly measured despite the positive use of technology to support women.

Technology can support the development of women's capacities and resources, in line with Mackey and Petrucka's (2021) work that analyzes the use of ICT interventions in outreach, education, lifestyle, prevention, health challenges, and perception barriers. They report the necessity of a collaborative

approach to address the gender gaps of ICT with united efforts and multi-sectoral involvement between researchers, program implementers, policymakers, and communities. In addition, interventions should include information to access education, entrepreneurship education, employment, and other resources for women. Digital literacy is mandatory for implementing learning systems, knowledge sharing, health and education interventions, among others. They include the importance of subsidies and support on infrastructure to acquire mobile devices or give support with the cost of telecommunication services and Subscriber Identity Module (SIM) cards to reduce gender accessibility gaps. Finally, as a further research agenda, they propose the inclusion of perception barriers and experiences regarding uptake, utilization, and ubiquity of ICTs.

Hazarika and Chakraborty (2019) use a gender perspective to work on a case study in different Indian districts, collecting information on the digital strategy to provide internet access and online infrastructure for citizens, particularly women. Some of the preliminary findings suggest mixed results. On the one hand, women failed to use technology appropriately influenced by patriarchal standards, have less exposure to technology, and inadequate training. On the other hand, specific programs such as “Internet Saathi” impacted the grassroots positively by starting a proper internet education and giving accessibility to women.

Several grassroots innovation cases can be analyzed in future research with a gender perspective that exemplifies the potential use of ICT4D at building alternative forms of community.

Bidwell (2020) includes the case of grassroots innovation in Argentina. Members of the community built and operated a decentralized telecommunication Community Networks (CNs) where hackers began to resist the dominant internet regime through peer collaboration. Lorini et al. (2019) present case studies in Cape Town, South Africa, where communities designed their use of ICT4D to enable egalitarian participation to grassroots innovations impacting empowerment and self-confidence in the community. Collectives engaged in processes and developed self-determined behaviors and cohesion.

Ghoshal et al. (2020) offer the perspective on social movements given by the Southern Movement Assembly (SMA) in the US, where people engaged with their movement history and grassroots culture of inclusion and participation despite the results in inequitable sociotechnical realities where people with technical skills gain more power and start to control organizational processes. Ghoshal et al. call for a grassroots culture of technology practice rooted in systemic exclusion analyses with a continuous effort to center the marginalized voices and experiences with technology. Bal and Baruh (2020) address the informal organizations created during and after the Occupy Movement in the United States and Gezi Park Protests in Turkey. They are characterized by distrust towards institutional political bodies and hierarchical organizations, including the opportunities and obstacles with the horizontal structures of such movements. Tye et al. (2018) present the case of Berish. This social media-enabled social movement pushed for electoral reform in Malaysia, where coordinated collective action produced a change in the community to exert public pressure on public institutions, proving that ICT plays a role in addressing complex social problems.

On community solidarity and inclusion, Giglito (2019) includes discussing the role that interactive digital technologies could play in facilitating community participation in cultural and heritage-related activities to foster social inclusion, where grassroots and community-led heritage initiatives work on participatory ICT disciplines such as human-computer interaction and community informatics.

Tim et al. (2021) offer an example of a case in China where grassroots communities in a remote county leveraged e-commerce to leapfrog out of poverty, becoming successful entrepreneurs with online businesses thriving on a global scale.

This work is instrumental in introducing several limitations of digital innovation e-commerce, such as a steep learning curve, and missing long-term strategy due to the lack of technical and managerial skills of the rural e-merchants, the absence of resources and support, the nature of local practices that are less agile and difficult to scale-up. On the bright side, the research includes breakthroughs such as 1) revitalizing traditional industries, bringing back some of the younger workforces to rural regions, transforming into online businesses, and improving living standards. 2) Quick leverage wins on resource availability rapidly, and the adoption of e-commerce brought significant improvement to the local economy. 3) Promoting local champions' integration and confidence by increasing business opportunities for the community in the e-commerce sector.

This article offers insights and recommendations for policymakers, public and private sector practitioners, and communities in underdeveloped regions to navigate both the potentials and pitfalls of technology leapfrogging and ultimately build a pathway towards resilience and sustainability.

Other cases present information about how technology affects different age groups given a digital policy. Zhou (2019) analyzes the Chinese social networking site (SNS), pointing out the complexity as a technical factor and Internet anxiety as a personal cognitive factor that hinders the elders. It also discusses the importance of social support as a facilitating condition that alleviates these problems' adverse effects and enhances Internet self-efficacy's positive effect, mainly because women use SNS less.

Some papers address the importance of national strategies. Longe et al. (2017) present Nigeria's case to address the digital divide at the grassroots and contribute to development by adopting ICT4D 2.0.

Finally, ICT is not only about the cases but about the design itself. Open design and inclusion are important for implantation of ICT based innovations at the grassroots. Green et al. (2019) propose a framework to analyze the open design aligned with the values and practices of free culture and open-source software and hardware, offering new perspectives on feminist and critical interventions into hacking and making open innovation bringing end-users and consumers into the design process. Making visible the debate between two schools of thought between the openness applied to technology design and the critiques of persisting forms of racial, gender, age, and class-based exclusions. Also, Devadula et al. (2017) mention the Gandhian approach to design necessarily emphasizes the designer and the context in which design happens, while the object could take a backstage giving a case study of InDeate tool, as 'service design' for the community workshops of National Innovation Foundation (NIF).

Main findings on research on grassroots and gendered innovation

National and local efforts in rural and urban environments

Contextual preparedness and a favorable environment at the national level are crucial for promoting entrepreneurship at the grassroots level. Tesfayohannes and Lee (2019) work on these ideas and propose implementing conceptual initiatives in the national arena. In particular, they propose action plans to accelerate the nation-building process in the context of the Horn of Africa countries, creating a conducive environment for the younger population to engage in entrepreneurial innovation activities.

The success of technology adoption needs gender responsive approaches to achieve social justice, especially in urban environments. Asteria et al. (2020) work on information gathering to conclude that social innovation in smart cities must require an understanding of technology users through community empowerment on women to promote equity in applying that technology. Capacity building and collaboration among governments and private partnerships are needed for citizens' preparedness for future smart cities and incorporate inclusive perspectives.

Predan's (2019) theoretical analysis includes how grassroots and participatory action can build new mechanisms of action outside the institutionalized culture. Women's participation in solidarity economies can strive for autonomy and give voice to the marginalized sector of society.

Participatory processes in a democracy are essential for citizens to gather evidence to hold governments accountable to their commitments. Balestra et al. (2018) study the implementation of Community-Based Monitoring (CBM) in a grassroots women's organization called Mahila Swasthya Adhikar Manch applicable to the health sector. The engagement of women and their power to demand change fosters women's political capabilities to mediate with the state and the relationship within communities. Nonetheless, more research is needed to measure the role of CBM in civil engagement at the grassroots level.

University alliances

Some documented cases talk about university alliances and the promotion of women at STEM (Science, Technology, Engineering, and Mathematics) and, more recently, the need to strengthen the capacity with SHAPE (Social sciences, Humanities, and Arts for People and the Economy). Aluko and Okuwa (2018) discuss the alliances and interaction of universities and communities to enhance innovation in process, products, and marketing in marginalized women in Nigeria. Rupert et al. (2020) include the importance of grassroots advocacy groups' formation to empower female scientists in training to make visible the underrepresented state of women in science.

Commercialization mechanisms

Sharma and Kumar (2019) present the problem analysis of commercialization mechanisms for innovations for grassroots to fit the demand and condition to local markets and the need for institutional support. They discussed how these innovations are being commercialized through social entrepreneurship, technology transfer, and open-source technology, where more research is needed to understand these

three kinds of market-oriented innovation for the grassroots. On a previous paper Sharma and Kumar (2018) proposed the use of utility models as an alternative of intellectual property protection for innovations that come from imitation and adaptation of the existing technologies that fall short for the patentability analysis and with this kind of protection promote and foster incremental and minor innovations emerging from the informal economy in the country.

Some social innovation cases introduce new forms of organization. The work of Cheema (2019) explains a model applied to the Pakistani context called "Business-in-a-Box" in which women are trained as community resource persons to sell health-related products in their communities such as household usage goods, health and hygiene commodities, short-term contraceptives as a micro-entrepreneur with micro-franchising models. They use this model to deliver some health interventions at the grassroots. This program creates continuity in seed investment and makes 80% of women financially stable and willing to continue working under this scheme. This study finds that these interventions can build a sense of community, ownership, and grassroots capabilities and skills. The article discusses the impacts on individual and community life, including the need to upscale and sustain these initiatives.

Financial support

Several studies have been taking upfront the discussion of intersectionality in mainframe policies in the past few decades, including lack of financial means. The work of Horton (2017) explains how microfinance programs can be used to empower women in low- and middle-income countries to promote innovation and also the adverse outcomes of this framework at the grassroots level considering how such market-based interventions intersect with patriarchal beliefs and practices and analyses the different mechanisms through which microfinance can empower or disempower women.

Limitations and conflicts

When dealing with interventions and human complexity, there will always be limitations and conflicts. Most papers talk about the limits to innovation and what we can learn. With an accelerated world, we need to pay attention to the backside and limitations of any policies or new frameworks to innovate. Besides the inclusion of programs where people are selected to participate in specific projects, there are other limitations such as capture, culture, and short-term view. This section includes some limitation projects, but several systemic biases and intersectionalities that frame barriers to innovation are treated further in the next section.

Ibrahim (2017) acknowledges that conflict, capture, and cooptation are potential limitations to social innovation and recognizes the role of contextual factors in initiating, implementing, and sustaining social innovations at the grassroots. Duarte et al. (2020) acknowledge gaps in the literature, particularly regarding the limited contributions illuminating processes and innovation determinants among social enterprises at the grassroots. Finally, Jones et al. (2021) address the problem of art centers in Australia given the cultural differences and commercial missions between the art workers and non – indigenous managers that provoke tensions in the social enterprises that can be worked through the family groups providing better support and mentoring.

Systemic biases and intersectional inequalities

In discussing the enabling features of ICT adoption, some critical voices point to the situated critiques of the dominant computer culture that recognize and challenge its systematic racial and gender biases. Abbate (2018) discusses the empowering outcome of coding skills for minorities given the systemic biases. Abbate argues through examples of historical coding movements in the US whether learning coding or computer science would be enough to create opportunity, given the many missing steps women and minorities encounter on the path between education and employment.

Gendered norms

Lindberg et al. (2016) recognize the necessity for a comprehensive approach to identifying and analyzing gendered norms, subordination, and empowerment that affect the aspired transition from social exclusion to social inclusion in social innovation processes.

Not gender neutral

Pecis (2016) states that gender and innovation are messy processes because they are corporeal, discursive, practical, and intertwined, confirming that innovation making is not gender-neutral. The term "positions of displacement" could be used to enhance the possibility of grasping the gender complexity created in these projects.

Access to services

Access to services can be an essential limitation for empowering women, promoting innovation when the basic needs of rural contexts are not fulfilled, and acknowledging different intersectionalities. Some research papers discuss the importance of programs funding primary access to services such as water security. Leder (2017) explores the concerns in Nepal, where two internationally funded programs aimed to empower women and promote leadership and grassroots entrepreneurs by improving access to water for both domestic and productive uses. But differences between women—such as age, marital status, caste, remittance flow, and land ownership—led to some women benefiting more than others urging to incorporate feminist understanding in communities' interventions and intra-household relations.

LGBTQI +

The inclusion of LGBTQI + communities and activism at the grassroots level is present in recent research linked with women empowerment. Lai (2018) links activism with the sense of gender equality in Hong Kong, where the government does not prioritize grassroots women's needs. This abandonment has allowed the flourishing of civil society and activism with migrants' domestic workers. In contrast with other LGBT + movements in Indonesia and the Philippines with migrant workers as part of the migrant workers' movement, sheds light on the circulation of transnational LGBTQI + networks and knowledge.

Best practices and expected outcomes

Leadership

Martiskainen (2017) emphasizes the importance of community leadership to develop this type of innovation that operates in niches and requires nurturing. Community leadership benefits from being embedded into social networks, shared vision, and decision making, but pre-existing skills and tacit knowledge also play a role. Community leaders can also assist niche building by working closely with intermediary actors.

Zuraik et al. (2020) employ survey reports where female leaders are engaged in less opening behaviors of ideation, risk-taking, and exploration and are perceived as less effective in leading innovation than males. As gender roles are evolving and diversified, new narratives are needed to explain an innovative female team leader. One way to overcome female leadership bias is the androgynous and ambidextrous lens that can transform misperceptions on leadership and create new standards. Stereotypes and prejudices limit innovation and women's opportunities. These findings imply that greater organizational support for women is needed since leadership is a critical component of visibility, compensation, and promotion. Organizations can benefit from innovation and resilience by doing so.

Pio et al. (2017) include some enablers to women's leadership in South Asia, including men's communities' involvement in what should change, greater economic participation by women, a supportive family, relevant leadership training, and grassroots advocacy, mentoring, and role models.

On leadership and decision making, Grabe and Dutt (2020) gathered information from community-level intervention in Nicaragua applying surveys that suggest the importance of assessing the psychosocial processes involved in transformative political spaces that facilitate women's political participation. This paper addresses the weight that will have to challenge and end gender-based power imbalances in local frameworks.

Education, training and construction of capabilities

One of the most vital enablers to grassroots women is education. Akello et al. (2017) include findings for better financial progress and welfare of women with Functional Adult Literacy (FAL) to acquire knowledge and skills to participate in Income Generating Activities and improve women's livelihood.

Ibrahim (2017) considers the limitations on individual capabilities at the grassroots, suggesting that collective agency acts are needed to generate new collective capabilities. Ibrahim argues that three processes are mandatory for promoting successful, scalable, and sustainable social innovations: conscientization, conciliation, and collaboration.

Singh et al. (2021) provide empirical evidence to support three factors of grassroots innovations influenced by entrepreneurial orientation affecting the success and economic and non-economic benefits, such as grassroots learning practices, local solutions, and networking capabilities.

Karawati et al. (2020) study the impacts on the implementation of women's entrepreneurship empowerment activities, finding that they can help empower rural women in the Indonesian study case, leading to a positive change in the quality of life of most families at the grassroots. Thus, improved family welfare and wellbeing.

Some case studies include skills and practices to improve the positive outcomes of grassroots innovation. Patnaik and Bhowmick (2019) study the implications of incorporating innovation management mechanisms such as learning practices, participatory design, and technology transfer to better outcomes of innovations in capacity building, women empowerment, creation of entrepreneurial opportunity, and technology transfer for promoting sustainability.

People with disabilities

There are several cases where technology can empower people with disabilities creating a more inclusive environment. Al Moaiqel et al. (2020) explore some best-emerging strategies for co-design of assistive technology (AT) for persons with disabilities (PWDs) to inspire grassroots exemplars utilizing a humanistic co-design approach to tailor need to those with visual, mobility, and speech-language impairments with open innovation. Another perspective is the Bennet et al. (2020) work that challenges the perspective on current approaches to AI and AT looking for care expressions. They report two forms of work that give rise to access and sensitizing concepts to help developers on human-computer interaction: (1) mundane attunements and (2) non-innocent authorizations. Cantin et al. (2020) analyze the importance of autonomy for PWDs, including a person with deafblindness when introduced to face-to-face communication assistive devices (CADs), reported having positive results on self-esteem and accessibility.

Technology commons and alternatives to the mainstream economy

Given the increasing attention to the emerging phenomenon of distributed innovation in commons-based peer production (CBPP) platforms, Aryan et al. (2021) present a comprehensive analysis and revision of the expected outcomes on CBPP where grassroots can create value-creation outside the current economic model with the emerging peer-to-peer innovations and traditional research and development. Digital innovations foster collaborative platforms that can facilitate networking and enable matchmaking of supply and demand. The emergence and structuration of digital innovations in the maker movement present an alternative construct of innovation wherein access to and sharing knowledge is predominantly distributed. In this model, the motives for contribution rely on communities, reciprocity, self-interest, pro-social behavior, and value systems.

Dey et al. (2019) contribute to the understanding of investment opportunities needed to innovate in high-risk environments. Like changing the perspective of a market-oriented environment with instruments more suitable for grassroots innovation such as Technology commons because of the blending of formal and informal knowledge systems. They propose strengthening the coping strategies of marginal farmers especially women including harnessing social and ethical capital sharing resources and knowledge; permanent access to resources and knowledge; innovation in products, processes, services and systems; building self-design and self-governed institutions and fostering distributed, decentralized and diversified innovations-based portfolios.

Alternative interactions and community networks are important to build trust and new ways to produce value. Gomez and Prado (2020) analyze an interesting case in Seville with a complementary currency called Puma created as a Local Exchange Trading Scheme. Puma functioned as a mutual credit system with a passbook and later as a digital wallet using a flat organization structure. Social innovations can regulate spaces to preserve solidarity and identity.

Networks and self-help groups

The importance of self-help groups for empowering women is another topic among researchers of grassroots innovation. Sreeraj (2020) analyzes the case of a self-help group AmritaSREE that has more than 300 thousand members in India to enhance the communication, dissemination, and empowerment of women and promote financial stability and self-empowerment among the women members. These solutions and networks seem to complement technology implementation, especially the internet of things (IoT) solutions discussed on Sreeraj (2020).

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Sustainability and renewable energy

One of the most critical conclusions regarding grassroots innovation and probably mentioned in every paper and research is the change needed for a more sustainable and fair future for everyone as discussed previously. There is increasing consideration in research on grassroots innovation of sustainability, alternative food systems, and renewable energy with a feminist perspective. This section includes some selected reviews about renewable energy and sustainability, mainly because the future of digital technology and the need for energy sources come together as related subjects.

Godden et al. (2020) focus on the work at the Asia Pacific Forum on Women, Law and Development (APWLD). They use Feminist Participatory Action Research (FPAR) to develop an alternative model, the 'Feminist Fossil Fuel Free Future' (5Fs), to strengthen grassroots women's movements and look for a more climate-just world with a gender perspective in economic, political, and social relationships. This program has shown very positive results in enhancing grassroots women's activism through capacity building, producing new knowledge, tools, and resources, undertaking impactful advocacy, and strengthening the movements' architecture.

Allen's (2019) research takes the case of two non-profit organizations in the US. They analyze that grassroots movements which focus on energy justice and democracy; they resist the fossil energy multinationals that promote disparities and inequities in energy. Also, NGOs look for community and public control to redistribute benefits and risks in the energy sector and, finally, they prioritize equity and justice with community ownership and distributed governance.

Some case studies are interesting because they include perspectives on grassroots innovation. Pellicer-Sifres (2020) explores the Transformative Energy Transition promoted by the energy grassroots initiatives

with a case study. They argue that they are systemic alternatives based on different values, technologies, policies, regulations, channels, sources of knowledge, and cultural patterns. Eales et al. (2020) present a case in Malawi, which has a rural electrification rate of 4%. They promote that social enterprises need to develop robust strategies for sustainability through fostering cross-sectoral linkages, investing in capacity building and awareness-raising. Also, they conclude about the necessity for research partnerships, budgeting, and resource planning conservatively. Finally, they should track social impact to inform business strategy, seek innovation in business planning, and utilize smart subsidies.

Documented cases and data sharing

Several initiatives are mentioned in the literature about grassroots innovation which can provide and create data for further research and analysis. The increasing research on grassroots innovation is impelled by both the growing interest in international alternatives for development, and the creation of information hubs to accelerate worldwide knowledge. The cases and papers used in this literature review, mention some interesting international cases worth mentioning as best practices or a lens for zooming the global agenda for grassroots innovations.

The Indian incubator called Gujarat Grassroot Innovation Augmentation Network (GIAN) from Honey Bee Network Institution is used in several Indian papers. Sharma and Kumar (2019) use this source as secondary data to conclude about the challenges of innovation and commercialization alternatives. Dey et al. (2019) acknowledge this network's evolution into several instruments for scouting, documenting, validating, and value-adding, financing, and disseminating innovations for, from, and with the grassroots. Joshi and Yenneti (2020) add to the GIAN, the People's Science Movements in India, and Social Technologies Network in Brazil looking for research on civil society involvement and innovation in social institutions and social arrangements. Singh et al. (2020) introduce the Grassroots technological innovation (GRTI) from the Indian context as a sustainable development source while addressing local problems and needs of people belonging to the bottom of the economic pyramid.

In the African context, Bobo (2017) tackles capacity innovation as a key feature for Africa's transformation using what is transformed in the African Union Development Agency-NEPAD (AUDA-NEPAD)⁴ and the Africa-MNC strategic alliance framework, a policy of one of the most important collaborations of African Heads of State. This policy conveys the philosophy of innovation capacity, innovation activity, and sustained transformation with a scheme to protect assets -human and physical- derived through the Africa-MNC strategic alliance.

Other papers consider the GENNOVATE research initiative that constitutes a community for global comparative research to address how gendered norms and agency influence men, women, and youth to adopt innovation in agriculture and resource management with a presence in 137 rural communities and 26 countries (GENNOVATE, 2018). This initiative comes from the CIGAR (Collaborative Platform for Gender Research), a global research partnership for a food secure future dedicated to poverty alleviation, enhancing food and nutrition, and improving natural resources. One of the branches offers the GENDER (Generating Evidence and New Directions for Equitable Results) platform offers a perspective and kick-start project for smallholder farmers around the world (GENDER – CIGAR, 2020), including information sharing from partners such as national agricultural research and extension systems, university partners,

⁴ The AUDA-NEPAD mandate to coordinate and execute priority regional and continental projects and strengthen African Union Member States and regional bodies' capacity, advance knowledge-based advisory support and resource mobilization as the continent's technical interface with stakeholders and development partners (AUDA – NEPAD, 2018).

non-government organization, multilateral institutions, and governments. Farnworth et al. (2020a) include a case in Bangladesh with women obtaining wheat-maize innovations and other documented research for women in India from Farnworth et al. (2020b). This second paper gathers data to analyze gender gaps, women challenging norms, and patriarchal environments to participate in innovation processes towards a topology for women strategies to encourage decision-making power in wheat production. Other works by the same authors are included in Nepal and Ethiopia using the GENNOVATE initiative to work on women and wheat production.

Nicolosi et al. (2020) include a noteworthy tool called Digitally mediated participatory mapping (DGPM), used to document grassroots initiatives and projects from a critical geographic information systems perspective worldwide. They investigate knowledge, inclusion and benefits, and complexities of the use of maps.

Towards feminist innovation in AI

We have created diverse, innovative methodologies to produce new and alternative forms of value. More than ever, alternatives to the mainstream economy are needed to understand some of society's most critical wicked problems. New technologies have the potential to democratize some advances and make alternative epistemologies more visible. Grassroots innovation and especially gendered innovations with a feminist perspective represent a vital framework to introduce and develop new ways to face, engage with and lead the digital future.

Feminist and gendered innovations seek to include diverse, traditionally marginalized perspectives into the analysis of innovation, technology, and ICT creation in frameworks of analysis to produce and help other people increase their visibility and capacity to create new forms of development. That includes scientific production and the construction of data ontologies and frameworks to create new alternatives for new technologies for artificial intelligence. It is imperative to have enough data with better quality to create new visions for the future and have a virtuous loop of constructive innovation cycles (Sarkki et al., 2021) for grassroots innovation and women empowerment.

This literature research advances, through the review of many research pieces that new alternatives and approaches are happening worldwide, creating new ways to engage and connect people. Technology allows knowledge and ideas to accelerate towards a better, more inclusive future. The practices and technology alternatives are being studied to fight inequalities and create better conditions in a world built on systemic and intersectional inequalities. New experiments and new ideas are yet to come.

In this construction of the future, there are essential issues to consider. The national and local efforts are significant because they frame what happens inside territories. Within these contexts, attention must be given to ensuring that diverse stakeholders are meaningfully engaged and empowered to lead change, starting with those whom the technology seek to serve. The quintuple helix (Carayannis, 2012; Grundel & Dahlström, 2016) needs better ways to connect and collaborate. Alliances with universities, organizations, social movements, and people are vital in creating a more open form of governance inside the nation-state framework. The financial needs and alternatives to impulse and build new technologies need better ways to create collective value through improved commercialization channels and achieve financial independence. None of this will be without limitations and conflicts within the new projects and stimulating discussions that change will generate, yet it will take us on the path towards inclusive change which truly responds to the realities and needs of the people traditionally left behind.

In a world where data is the oxygen for technology and artificial intelligence, we need new lungs as frameworks for this new world. Systemic biases and intersectional inequalities are embedded in the ontology of technology. There are gender norms that create the results of what we are building. Feminism is a framework with different ethics and openness to build new ways to navigate reality and allow diversity to be included in creating the new generation of technologies.

New leadership is needed from empowered women to incorporate their vision in a patriarchal system and make it more inclusive. Importantly, we must also commit to including and hearing the voices of those most marginalized, recognizing their expertise and experiences. Education is also a very important element. We must create new generation with critical thinking abilities, with skills to build technologies and imagine a new future. Give importance to traditional knowledge and create new perspectives for intellectual property systems with open innovation and technology commons. The creation of networks

to build resilience and exchange values and information to build a more sustainable world to create the energy needed for new technologies with greener alternatives.

All of the above needs new alliances and information hubs to share and enable people to come together to build the tools needed from the grassroots up, as an alternative to the mainstream ideas of innovation and development. This literature review and its conclusions constitute a few ideas to start building this project, but innovation is a process and is cycling. Let us construct the next loop.

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