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Participatory Approaches to Agricultural Research and Extension Services

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Participatory approaches in agricultural research and extension services have increasingly been recognized over recent decades as effective strategies for engaging farmers, integrating their expertise and preferences, and developing locally appropriate solutions. This article explores the

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various participatory methods used globally, particularly emphasizing practices in Asia and India. It traces the historical development of these approaches, outlines their core principles and methodologies, and presents evidence of their impact on agricultural productivity, sustainability, and the livelihoods of farmers. Through diverse case studies, including farmer field schools and participatory plant breeding, the article highlights the wide range of participatory techniques implemented in different regions. Additionally, it addresses the challenges and criticisms of participatory methods and suggests future directions for research and practice. Participatory approaches hold significant potential to enhance the responsiveness of agricultural research and extension services to the needs, knowledge, and creativity of farmers. Nonetheless, these approaches necessitate substantial investments in capacity building, institutional reforms, and policy adjustments to foster an environment conducive to participatory innovation. Continued research is crucial to evaluate the long-term effects and to facilitate the scaling up of successful participatory models.

Keywords: Participatory approaches; agricultural research; extension services; livelihoods; sustainability.

1. INTRODUCTION

Agriculture remains the lifeblood of many developing countries, providing livelihoods, food security and export earnings. However, agricultural productivity and sustainability face numerous challenges, from climate change to land degradation to market fluctuations [1]. Traditional top-down models of agricultural research and extension, where scientists develop technologies and extension agents disseminate them to farmers, have had limited success in addressing these challenges [2].

In response, participatory approaches that engage farmers as active partners in research and innovation have gained prominence since the 1980s [3]. These approaches build on farmers' local knowledge, priorities and creativity to develop locally-relevant solutions [4]. They range from consultative methods that seek farmers' input, to collaborative methods that involve farmers in technology design and experimentation, to collegial methods that support farmer-led innovation [5].

This article reviews the evolution, principles, methods and impacts of participatory approaches to agricultural research and extension worldwide, with a focus on Asia and India. It draws on scholarly literature, project reports, and practitioner accounts to provide a comprehensive overview of the field. The article is structured as follows: Section 2 traces the origins and evolution of participatory approaches; Section 3 outlines key principles and methodologies; Section 4 presents case studies from various countries; Section 5 synthesizes evidence on impacts; Section 6 discusses challenges and critiques; and Section 7 concludes with future directions for research and practice.

2. EVOLUTION OF PARTICIPATORY APPROACHES

Participatory approaches to agricultural research and extension emerged in the 1980s, influenced by the work of Robert Chambers and others on participatory rural appraisal (PRA) and farmer first approaches [6]. These approaches arose in response to the limitations of transfer-of-technology models, which assumed that scientists had superior knowledge and that farmers were passive adopters [7].

In contrast, participatory approaches recognized farmers' local knowledge, skills and agency in innovation processes. They sought to empower farmers to analyze their own problems, experiment with solutions, and share knowledge with peers [8]. Early examples included the farmer-back-to-farmer model developed by Rhoades and Booth [9], and the farmer first and last model proposed by Chambers and Ghildyal [10].

In the 1990s, participatory approaches expanded and diversified, encompassing a range of methodologies such as participatory technology development (PTD), participatory plant breeding (PPB), participatory varietal selection (PVS), and farmer field schools (FFS) [11]. These approaches involved farmers in various stages of the research and innovation process, from problem diagnosis to technology design to evaluation.

In the 2000s, participatory approaches continued to evolve, with greater emphasis on farmer-led innovation, social learning, and multi-stakeholder partnerships [12]. Approaches such as participatory innovation development (PID) and participatory market chain analysis (PMCA) emerged to support farmer entrepreneurship and market access [13]. There was also growing recognition of the need to scale up participatory approaches and to create enabling policies and institutions [14].

3. PRINCIPLES AND METHODOLOGIES

Participatory approaches to agricultural research and extension are guided by several key principles [15]:

- Farmers have valuable knowledge, skills and creativity that can contribute to innovation
- Farmers should be actively engaged in all stages of the research and innovation process
- Research should address farmers' priorities, needs and constraints
- Technologies should be developed and adapted to local conditions and contexts
- Innovation is a social process that involves learning, negotiation and collective action

Based on these principles, participatory approaches employ a variety of methodologies, tools and techniques to engage farmers and other stakeholders. Some common methodologies include [16]:

Participatory rural appraisal (PRA): A family of methods that enable farmers to analyze their own situation, problems and resources, using visual and interactive tools such as mapping, ranking, and diagramming.

Participatory technology development (PTD): A process of joint inquiry and experimentation involving farmers, researchers and extension agents to develop, test and adapt new technologies to local conditions.

Participatory plant breeding (PPB): A collaborative process where farmers and plant breeders work together to develop new crop varieties that meet farmers' needs and preferences, using local landraces and improved materials.

Participatory varietal selection (PVS): A method where farmers evaluate and select promising crop varieties from a range of options, based on their own criteria and conditions.

Farmer field schools (FFS): A group-based learning approach where farmers meet regularly in the field to observe, experiment, and learn about crop management practices, pest ecology, and other topics.

Participatory market chain analysis (PMCA): A process that engages farmers, traders, processors, and other market actors to identify opportunities and innovations to improve the performance of value chains.

Citizen science: An approach that involves farmers and other citizens in collecting data, monitoring environmental conditions, and contributing to scientific research.

Information and communication technologies (ICTs): Tools such as mobile phones, radio, video, and social media that enable farmers to access information, share knowledge, and participate in research and extension activities.

4. CASE STUDIES

This section presents case studies of participatory approaches to agricultural research and extension from different countries and regions, illustrating their diversity and impacts.

Table 1. Evolution of participatory approaches to agricultural research and extension

Decade	Key Approaches and Methodologies
1970s	Farming systems research (FSR)
1980s	Participatory rural appraisal (PRA), Farmer-back-to-farmer model, Farmer first and last model
1990s	Participatory technology development (PTD), Participatory plant breeding (PPB), Participatory varietal selection (PVS), Farmer field schools (FFS)
2000s	Participatory innovation development (PID), Participatory market chain analysis (PMCA), Scaling up and institutionalization
2010s	Farmer-led research, Citizen science, ICT-enabled participation, Multi-stakeholder innovation platforms

Source: Author's compilation based on [3,4,11,12,14]

Table 2. Participatory methodologies and their key features

Methodology	Key Features
Participatory rural appraisal (PRA)	- Enables farmers to analyze their situation and resources - Uses visual and interactive tools like mapping and ranking
Participatory technology development (PTD)	- Joint inquiry and experimentation by farmers and researchers - Develops and adapts technologies to local conditions
Participatory plant breeding (PPB)	- Farmers and breeders collaborate to develop new varieties - Uses local landraces and improved materials
Participatory varietal selection (PVS)	- Farmers evaluate and select crop varieties based on their criteria - Facilitates feedback to breeding programs
Farmer field schools (FFS)	- Group-based learning in the field - Farmers experiment and learn about crop management and ecology
Participatory market chain analysis (PMCA)	- Engages market actors to identify opportunities and innovations - Focuses on improving the performance of value chains
Citizen science	- Involves farmers in data collection and research - Expands scale and scope of agricultural research
ICT-enabled participation	- Uses mobile phones, radio, video, and social media to share knowledge. - Enables remote participation and wider reach

Source: [16,17,18]

4.1 Farmer Field Schools in Indonesia

Farmer Field Schools (FFS) originated in Indonesia in the late 1980s as a way to promote integrated pest management (IPM) in rice production [19]. The approach was developed by the UN Food and Agriculture Organization (FAO) and partners in response to the harmful impacts of pesticide use on human health and the environment.

FFS involves groups of 20-25 farmers who meet weekly in the field to observe and analyze the agro-ecosystem, conduct experiments, and learn about crop management practices [20]. The curriculum is based on experiential learning cycles, where farmers identify problems, develop hypotheses, collect data, and make decisions based on their observations.

Over the years, FFS has expanded to cover a range of crops and topics beyond IPM, such as soil fertility management, water conservation, and climate change adaptation [21]. They have also been adapted to different contexts and countries in Asia, Africa, and Latin America.

Studies have shown that FFS can have significant impacts on farmers' knowledge, adoption of sustainable practices, and productivity [22]. For example, a meta-analysis of 25 studies found that FFS participants had 13% higher yields and 20% higher profits than non-participants [23]. FFS have also empowered farmers to make informed decisions, reduce pesticide use, and conserve biodiversity [24].

However, challenges remain in scaling up FFS and ensuring their financial sustainability [25]. Some critics argue that FFS are too intensive and costly for large-scale extension and that they may not reach the poorest farmers [26]. Others point out that FFS needs to be complemented by other services such as input supply, credit, and market access [27].

4.2 Participatory Plant Breeding in India

Participatory plant breeding (PPB) is a collaborative process where farmers and breeders work together to develop new crop varieties that meet farmers' needs and preferences [28]. PPB can take various forms, from farmers selecting from a range of varieties provided by breeders to farmers actively involved in cross-breeding and selection throughout the breeding cycle.

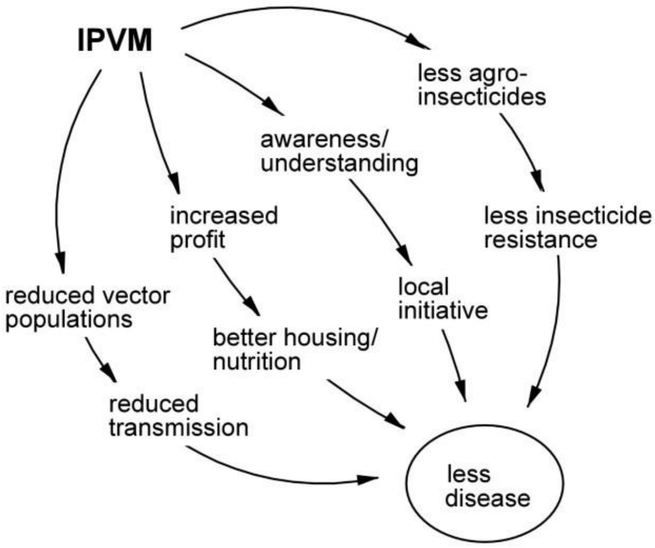

Fig. 1. Farmer field school cycle
Source: [20]

Table 3. Comparison of conventional and participatory plant breeding

Aspect	Conventional Plant Breeding	Participatory Plant Breeding
Goal	Develop high-yielding, widely-adapted varieties	Develop locally-adapted varieties that meet farmers' needs
Process	Linear, researcher-driven	Iterative, collaborative, farmer-driven
Selection environment	Research stations, controlled conditions	Farmers' fields, local conditions
Varietal traits	Yield, resistance to major diseases	Multiple traits based on farmers' preferences
Evaluation	Researcher-managed trials	Farmer-managed trials, mother-baby design
Seed dissemination	Formal seed systems, commercial channels	Informal seed systems, farmer-to-farmer exchange
Empowerment	Limited, farmers as passive recipients	High, farmers as active participants and decision-makers

Source: Author's compilation based on [28,32,34]

In India, PPB has been used to develop locally-adapted varieties of crops such as rice, maize, sorghum, and minor millets [29]. One example is the Ashoka 200F maize hybrid, which was developed through a collaboration between farmers, NGOs, and the Indian Council of Agricultural Research (ICAR) [30].

The process started with a participatory rural appraisal to identify farmers' preferences for maize traits, such as early maturity, drought tolerance, and fodder quality. Breeders then provided a range of maize lines for farmers to evaluate and select in their own fields, using a mother-baby trial design. After several cycles of selection, the Ashoka 200F hybrid was identified as a promising variety that met farmers' criteria.

The Ashoka 200F hybrid has since been adopted by thousands of farmers in several states of India, who appreciate its early maturity, high yield, and fodder quality [31]. It has also been licensed to private seed companies for commercialization, generating revenue for the public breeding program.

Studies have shown that PPB can lead to the development of varieties that are well-adapted to local conditions, preferred by farmers, and adopted more quickly than conventional bred varieties [32]. PPB can also empower farmers, especially women and marginalized groups, to participate in the innovation process and make informed choices [33].

However, PPB requires a shift in the roles and attitudes of researchers and extensionists, from being experts to facilitators and learners [34]. It also requires supportive policies and institutions, such as intellectual property rights that recognize farmers' contributions, and seed systems that allow for the dissemination of locally-developed varieties [35].

4.3 Participatory Market Chain Analysis in Peru

Participatory Market Chain Analysis (PMCA) is an approach that engages smallholder farmers, traders, processors, and other market actors to identify opportunities for innovation in value chains [36]. PMCA was developed by the International Potato Center (CIP) and partners in Peru in the early 2000s, and has since been applied to various crops and contexts in Latin America, Africa, and Asia [37].

PMCA involves three phases: diagnosis, analysis, and innovation. In the diagnosis phase, facilitators and market chain actors conduct a rapid appraisal of the market chain to identify key actors, their roles, and the challenges they face. In the analysis phase, actors come together in thematic groups to analyze potential business opportunities and develop a shared vision for the market chain. In the innovation phase, actors work together to develop and test new products, technologies or institutional arrangements that can improve the competitiveness and inclusiveness of the market chain [38].

One example of PMCA in Peru is the development of a new brand of high-quality coffee by a cooperative of smallholder farmers in San Martin province [39]. Through the PMCA process, the cooperative identified an opportunity to differentiate its coffee based on its unique flavor profile and social and environmental attributes. They worked with researchers, extension agents, and buyers to improve their production and post-harvest practices, develop a brand identity, and access specialty coffee markets in Europe.

As a result of the PMCA intervention, the cooperative was able to increase its coffee quality, obtain organic and fair trade certification, and negotiate higher prices for its branded coffee [40]. They also strengthened their internal organization and their relationships with other actors in the market chain. The cooperative's experience has inspired other farmer groups in the region to pursue similar strategies of value addition and market differentiation.

Studies have shown that PMCA can lead to tangible benefits for smallholder farmers, such as increased income, access to new markets, and improved bargaining power [41]. PMCA can also foster social learning, trust, and collaboration among market chain actors, which are essential for sustained innovation [42].

However, PMCA is not a panacea for all the challenges facing smallholder farmers in developing countries. It requires skilled facilitation, long-term commitment, and an enabling environment that supports collective action and innovation [43]. PMCA also needs to be adapted to different contexts and commodities, taking into account power dynamics, gender roles, and cultural norms [44].

5. IMPACTS OF PARTICIPATORY APPROACHES

Participatory approaches to agricultural research and extension have been promoted as a way to enhance the relevance, effectiveness, and sustainability of innovation processes.

5.1 Technology Adoption

Several studies have shown that participatory approaches can lead to higher rates of technology adoption compared to conventional approaches. For example, a meta-analysis of 25 studies on participatory research and extension found that participatory approaches increased adoption rates by an average of 68% [45].

Another study in Kenya found that farmers who participated in a participatory maize breeding program were more likely to adopt the new varieties than non-participants, due to their involvement in the selection process and their trust in the program [46]. Similarly, a study in India found that farmers who were involved in the participatory varietal selection of rice adopted the selected varieties more quickly and widely than farmers who received the varieties through conventional extension [47].

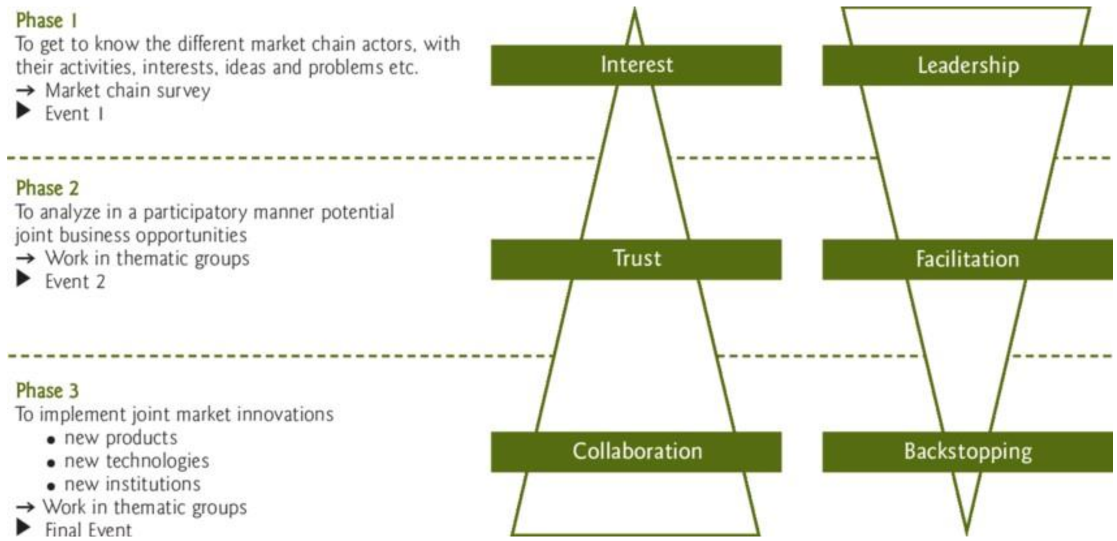

Fig. 2. Participatory market chain analysis process
Source: [38]

However, the impact of participatory approaches on adoption may vary depending on the type of technology, the socio-economic context, and the characteristics of the participating farmers. For instance, a study in Malawi found that participatory research had a positive impact on the adoption of soil fertility management practices, but not on the adoption of improved maize varieties [48].

5.2 Productivity and Income

Participatory approaches have also been shown to increase agricultural productivity and farmer incomes in many cases. A review of 14 studies on participatory plant breeding found that participatory bred varieties had an average yield advantage of 12.6% over conventional varieties, with some studies showing yield gains of up to 40% [49]. Another study in Honduras found that farmers who participated in a participatory bean breeding program had 17% higher yields and 24% higher incomes than non-participants, due to the improved varieties and management practices they adopted [50]. Similarly, a study in Nepal found that farmers who were involved in participatory variety selection of rice had 15-30% higher yields than farmers who grew traditional varieties [51].

However, the impact of participatory approaches on productivity and income may be influenced by factors such as the agro-ecological context, market access, and institutional support. For example, a study in Syria found that participatory breeding of barley led to significant yield gains in drought-prone areas, but not in favorable environments where conventional varieties performed well [52]. Another study in Colombia found that participatory research on integrated pest management in potato had limited impact on yields and income, partly due to the lack of market incentives and infrastructure for producing high-quality potatoes [53].

Table 4. Examples of impacts of participatory approaches on productivity and income

Country	Crop	Participatory Approach	Impact
Honduras	Beans	Participatory breeding	17% higher yields, 24% higher income for participants
Nepal	Rice	Participatory varietal selection	15-30% higher yields for participants
Syria	Barley	Participatory breeding	Yield gains in drought-prone areas, not in favorable environments
Colombia	Potato	Participatory IPM research	Limited impact on yields and income due to market constraints

Source: [49,50,51,52,53]

5.3 Empowerment and Social Capital

Participatory approaches can also have important social and institutional impacts, such as empowering farmers, building social capital, and promoting collective action. By involving farmers as active participants and decision-makers in the research and innovation process, participatory approaches can enhance their confidence, knowledge, and skills [54].

For example, a study in Burkina Faso found that farmers who participated in a participatory sorghum breeding program had increased self-esteem, social recognition, and leadership roles in their communities [55]. They also formed new networks and solidarities with other farmers, researchers, and extension agents, which facilitated the exchange of knowledge and resources.

Another study in India found that participatory varietal selection of rice led to the formation of farmer groups and cooperatives, which enabled collective marketing and bargaining with traders [56]. The study also found that women farmers who were involved in the participatory process had greater access to and control over seeds, which enhanced their food security and autonomy.

However, the empowerment and social capital impacts of participatory approaches may be limited by existing power relations and inequalities in the community. A study in Uganda found that participatory research on soil fertility management had different impacts on men and women farmers, due to their different roles, resources, and constraints [57]. The study suggests that participatory approaches need to be designed and implemented in a gender-sensitive way, taking into account the specific needs and priorities of women and other marginalized groups.

5.4 Sustainability and Resilience

Participatory approaches can also contribute to the sustainability and resilience of agricultural systems, by promoting the use of locally adapted, diverse, and environment-friendly practices [58]. By building on farmers' indigenous knowledge and innovation capacities, participatory approaches can help conserve agrobiodiversity, reduce external inputs, and enhance the adaptive capacity of farming communities. For example, a study in Mexico found that participatory maize breeding led to the development of varieties that were more resistant to drought, pests, and diseases than conventional varieties, and that maintained the genetic diversity of local landraces [59]. The study also found that the participatory process strengthened the cultural identity and social cohesion of the farming communities, which are important for their resilience to climate and market shocks.

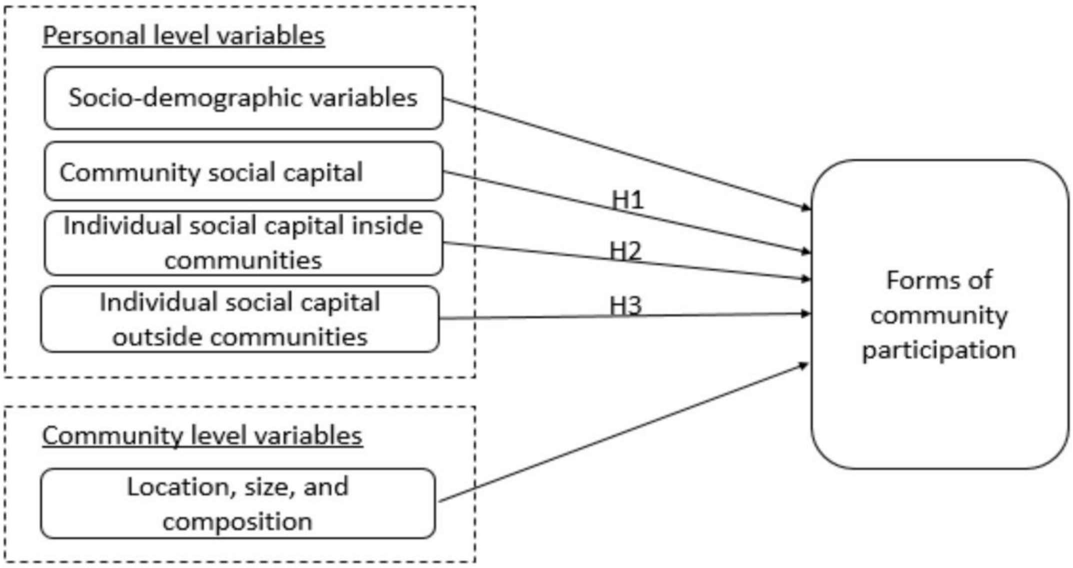

Fig. 3. Empowerment and social capital impacts of participatory approaches
Source: [54,55,56,57]

Another study in the Philippines found that participatory research on agroforestry systems led to the adoption of more diverse and integrated farming practices, such as intercropping, composting, and rainwater harvesting [60]. These practices not only improved soil fertility, water conservation, and crop yields, but also provided a range of ecosystem services, such as carbon sequestration, biodiversity conservation, and landscape beautification. However, the sustainability and resilience impacts of participatory approaches may be constrained by external factors, such as market pressures, land tenure insecurity, and climate variability. A study in Nicaragua found that participatory research on cover crops and reduced tillage had limited adoption by farmers, due to the lack of market incentives for sustainable practices and the high cost of inputs [61]. Another study in Kenya found that participatory water management had uneven impacts on different groups of farmers, due to their differentiated access to land, labor, and capital [62]. The study suggests that participatory approaches need to be complemented by supportive policies and institutions, such as payments for ecosystem services, land reforms, and safety nets, to create an enabling environment for sustainable and equitable agricultural development.

6. CHALLENGES AND CRITIQUES

Despite the growing evidence of their positive impacts, participatory approaches to agricultural research and extension also face several challenges and critiques. This section discusses some of the key issues and debates around participatory approaches.

6.1 Scalability and Cost-Effectiveness

One of the main challenges of participatory approaches is their scalability and cost-effectiveness. Participatory approaches are often more time-consuming, resource-intensive, and context-specific than conventional approaches, which can limit their applicability to large-scale extension programs [63].

Table 5. Examples of sustainability and resilience impacts of participatory approaches

Country	Farming System	Participatory Approach	Impact
Mexico	Maize-based systems	Participatory maize breeding	Drought and pest resistant varieties, conserved agrobiodiversity
Philippines	Agroforestry systems	Participatory agroforestry research	Diverse and integrated practices, improved soil fertility and ecosystem services
Nicaragua	Maize-bean systems	Participatory research on conservation agriculture	Limited adoption due to lack of market incentives and high input costs
Kenya	Irrigation systems	Participatory water management	Uneven impacts due to differentiated access to resources

Source: [59,60,61,62]

Table 6. Challenges and critiques of participatory approaches

Challenge	Description	Examples
Scalability and cost-effectiveness	Participatory approaches are often time-consuming, resource-intensive, and context-specific, limiting their scalability	- High upfront costs and low relevance of farmer field schools in Tanzania- Low diffusion and sustainability of participatory plant breeding in India
Power relations and inclusivity	Participatory approaches may reinforce or exacerbate power relations and inequalities within communities, especially for marginalized groups	- Limited involvement of women in participatory aquaculture research in Bangladesh- Bias towards male farmers' preferences in participatory varietal selection in Peru
Scientific rigor and validity	Participatory approaches are perceived as less objective, reliable, and generalizable than conventional research methods	- High variability and inconsistency of participatory variety selection in Ethiopia- Low farmer participation and data quality of participatory on-farm trials in Malawi

Source: [63,64,65,68,69,70,73,74,75]

For example, a study in Tanzania found that farmer field schools on integrated pest management had high upfront costs for training and facilitation, and that the knowledge and practices promoted were not always relevant or feasible for farmers in different agro-ecological zones [64]. Another study in India found that participatory plant breeding had a high turnover of farmers and a low diffusion of varieties beyond the participating communities, due to the lack of seed production and dissemination systems [65]. Some scholars argue that participatory approaches need to be scaled up through a combination of vertical and horizontal strategies, such as linking with formal extension systems, using mass media and ICTs, and promoting farmer-to-farmer exchange [66]. Others suggest that participatory approaches should be seen as a complement rather than a substitute for conventional approaches and that they should be targeted to specific contexts and objectives where they have a comparative advantage [67].

6.2 Power Relations and Inclusivity

Another challenge of participatory approaches is their potential to reinforce or exacerbate power relations and inequalities within communities. Participatory approaches may not automatically benefit marginalized groups, such as women, youth, and indigenous peoples, who often have less access to resources, information, and decision-making processes [68].

For example, a study in Bangladesh found that participatory research on aquaculture had limited involvement of women, due to cultural norms that restricted their mobility and interactions with male researchers and extension agents [69]. Another study in Peru found that participatory varietal selection of potatoes favored the preferences of male farmers, who prioritized market-oriented traits, over those of women farmers, who valued culinary and nutritional traits [70].

Some scholars argue that participatory approaches need to be more inclusive and transformative, by challenging the underlying power structures and discrimination that perpetuate poverty and inequality [71]. This may require using more critical and reflexive methodologies, such as feminist participatory action research, participatory video, and citizen juries, which enable marginalized groups to voice their perspectives and advocate for their rights [72].

6.3 Scientific Rigor and Validity

A third challenge of participatory approaches is their perceived lack of scientific rigor and validity. Some scientists and policymakers view participatory approaches as less objective, reliable, and generalizable than conventional research methods, which rely on statistical sampling, experimental designs, and peer review [73].

For example, a study in Ethiopia found that participatory variety selection of sorghum had a high degree of variability and inconsistency across locations and years, due to the influence of farmers' subjective preferences and environmental factors [74]. Another study in Malawi found that participatory on-farm trials of legume technologies had a low level of farmer participation and data quality, due to the lack of incentives and monitoring by researchers [75].

Some scholars argue that participatory approaches need to be more systematic and rigorous, by using mixed methods, triangulation, and quality control measures to ensure their credibility and reproducibility [76]. Others suggest that participatory approaches should be evaluated based on their own criteria of relevance, effectiveness, and impact, rather than on conventional scientific standards [77].

7. CONCLUSION AND FUTURE DIRECTIONS

Participatory approaches to agricultural research and extension have evolved over the past few decades, as a response to the limitations of top-down, linear models of innovation. By engaging farmers as active partners and decision-makers in the research and innovation process, participatory approaches aim to enhance the relevance, effectiveness, and sustainability of agricultural development. However, participatory approaches also face several challenges and critiques, related to their scalability, inclusivity, and scientific rigor. To address these challenges and realize the full potential of participatory approaches, several future directions are proposed:

1. **Scaling up and institutionalizing participatory approaches:** This may require developing and testing new models and strategies for integrating participatory approaches into formal research and extension systems, as well as creating an

enabling policy and institutional environment for participatory innovation.
2. **Enhancing the inclusivity and equity of participatory approaches:** This may involve using more critical and transformative methodologies that challenge power relations and discrimination, as well as targeting and empowering marginalized groups, such as women, youth, and indigenous peoples.
3. **Strengthening the scientific rigor and credibility of participatory approaches:** This may entail using more systematic and mixed methods for data collection and analysis, as well as developing and applying appropriate criteria and indicators for evaluating the quality and impact of participatory research.
4. **Promoting learning and knowledge sharing among participatory practitioners:** This may require establishing and supporting networks, platforms, and communities of practice that enable practitioners to exchange experiences, tools, and lessons learned, as well as to co-create new knowledge and innovations.
5. **Investing in capacity building and education for participatory approaches:** This may involve developing and delivering training programs, curricula, and materials that equip researchers, extensionists, and farmers with the skills, attitudes, and values needed for effective participatory engagement.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. FAO. The future of food and agriculture: Trends and challenges. Rome: Food and Agriculture Organization of the United Nations; 2017.
2. Chambers R. Rural development: Putting the last first. London: Longman; 1983.
3. Chambers R. The origins and practice of participatory rural appraisal. World Development. 1994;22(7):953-969.
4. Ashby JA. The effects of different types of farmer participation on the management of on-farm trials. Agricultural Administration and Extension. 1987;25(4):235-252.
5. Biggs SD. Resource-poor farmer participation in research: A synthesis of experiences from nine national agricultural research systems. OFCOR Comparative Study Paper No. 3. The Hague: International Service for National Agricultural Research; 1989.
6. Chambers R, Pacey A, Thrupp LA. (Eds.). Farmer first: Farmer innovation and agricultural research. London: Intermediate Technology Publications; 1989.
7. Röling N. Extension science: Information systems in agricultural development. Cambridge: Cambridge University Press; 1988.
8. Pretty JN. Participatory learning for sustainable agriculture. World Development. 1995;23(8): 1247-1263.
9. Rhoades RE, Booth RH. Farmer-back-to-farmer: A model for generating acceptable agricultural technology. Agricultural Administration. 1982;11(2):127-137.
10. Chambers R, Ghildyal BP. Agricultural research for resource-poor farmers: The farmer-first-and-last model. Agricultural Administration. 1985;20(1):1-30.
11. Sperling L, Ashby JA, Smith ME, Weltzien E, McGuire S. A framework for analyzing participatory plant breeding approaches and results. Euphytica. 2001;122(3):439-450.
12. Sumberg J, Okali C, Reece D. Agricultural research in the face of diversity, local knowledge and the participation imperative: Theoretical considerations. Agricultural Systems. 2003;76(2):739-753.
13. Bernet T, Thiele G, Zschocke T. Participatory Market Chain Approach (PMCA): User guide. Lima: International Potato Center; 2006.
14. Douthwaite B, Beaulieu N, Lundy M, Peters D. Understanding how participatory approaches foster innovation. International Journal of Agricultural Sustainability. 2009;7(1):42-60.
15. Hellin J, Bellon MR, Badstue L. Reducing the gap between researchers' and farmers' realities. International Journal of Agricultural Sustainability. 2006;4(2):186-195.

16. Neef A, Neubert D. Stakeholder participation in agricultural research projects: A conceptual framework for reflection and decision-making. Agriculture and Human Values. 2011;28(2):179-194.
17. Martin A, Sherington J. Participatory research methods—implementation, effectiveness and institutional context. Agricultural Systems. 1997;55(2):195-216.
18. Lilja N, Bellon M. Some common questions about participatory research: A review of the literature. Development in Practice. 2008;18(4-5):479-488.
19. van de Fliert E, Braun AR. Conceptualizing integrative, farmer participatory research for sustainable agriculture: From opportunities to impact. Agriculture and Human Values. 2002;19(1):25-38.
20. Braun AR, Thiele G, Fernández M. Farmer field schools and local agricultural research committees: Complementary platforms for integrated decision-making in sustainable agriculture. Agricultural Research & Extension Network Paper No. 105. London: Overseas Development Institute; 2000.
21. Friis-Hansen E, Duveskog D. The empowerment route to well-being: An analysis of farmer field schools in East Africa. World Development. 2012;40(2): 414-427.
22. Davis K, Nkonya E, Kato E, Mekonnen DA, Odendo M, Miiro R, Nkuba J. Impact of farmer field schools on agricultural productivity and poverty in East Africa. World Development. 2012;40(2):402-413.
23. Waddington H, Snilstveit B, Hombrados J, Vojtkova M, Phillips D, Davies P, White H. Farmer field schools for improving farming practices and farmer outcomes: A systematic review. Campbell Systematic Reviews. 2014;10(1):i-335.
24. Kenmore PE. Integrated pest management in rice. In E. B. Radcliffe & W. D. Hutchison (Eds.), Radcliffe's IPM World Textbook St. Paul: University of Minnesota. 1996;76-97.
25. Quizon J, Feder G, Murgai R. Fiscal sustainability of agricultural extension: The case of the farmer field school approach. Journal of International Agricultural and Extension Education. 2001;8(1):13-24.
26. Tripp R, Wijeratne M, Piyadasa VH. What should we expect from farmer field schools? A Sri Lanka case study. World Development. 2005;33(10):1705-1720.
27. Feder G, Murgai R, Quizon JB. The acquisition and diffusion of knowledge: The case of pest management training in farmer field schools, Indonesia. Journal of Agricultural Economics. 2004;55(2):221-243.
28. Weltzien E, Smith ME, Meitzner LS, Sperling L. Technical and institutional issues in participatory plant breeding from the perspective of formal plant breeding: A global analysis of issues, results, and current experience. CGIAR Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation, Working Document No. 3. Cali: CIAT; 2003.
29. Chaudhary P, Sthapit B. Agricultural biodiversity conservation and food security in the context of climate change in Nepal. In W. S. de Boef, A. Subedi, N. Peroni, M. Thijssen, & E. O'Keeffe (Eds.), Community Biodiversity Management: Promoting Resilience and the Conservation of Plant Genetic Resources. 2013;249-256.
30. Witcombe JR, Joshi A, Joshi KD, Sthapit BR. Farmer participatory crop improvement. I. Varietal selection and breeding methods and their impact on biodiversity. Experimental Agriculture. 1996;32(4):445-460.
31. Joshi KD, Musa AM, Johansen C, Gyawali S, Harris D, Witcombe JR. Highly client-oriented breeding, using local preferences and selection, produces widely adapted rice varieties. Field Crops Research. 2007;100(1):107-116.
32. Ceccarelli S. Efficiency of plant breeding. Crop Science. 2015;55(1):87-97.
33. Galiè A, Jiggins J, Struik PC. Women's identity as farmers: A case study from ten households in Syria. NJAS-Wageningen Journal of Life Sciences. 2013;64:25-33.
34. Morris ML, Bellon MR. Participatory plant breeding research: Opportunities and challenges for the international crop improvement system. Euphytica. 2004; 136(1):21-35.
35. Sperling L, Loevinsohn ME, Ntabomvura B. Rethinking the farmer's role in plant breeding: Local bean experts and on-station selection in Rwanda. Experimental Agriculture. 1993;29(4):509-519.
36. Bernet T, Thiele G, Zschocke T. Participatory Market Chain Approach (PMCA): User Guide. Lima: International Potato Center; 2006.
37. Devaux A, Horton D, Velasco C, Thiele G, López G, Bernet T, Reinoso I, Ordinola M.

Collective action for market chain innovation in the Andes. Food Policy. 2009;34(1):31-38.
38. Thiele G, Devaux A, Reinoso I, Pico H, Montesdeoca F, Pumisacho M, Andrade-Piedra J, Velasco C, Flores P, Esprella R, Thomann A, Manrique K, Horton D. Multi-stakeholder platforms for linking small farmers to value chains: Evidence from the Andes. International Journal of Agricultural Sustainability. 2011;9(3):423-433.
39. Horton D, Rotondo E, Paz Ybarnegaray R, Hareau G, Devaux A, Thiele G. Lapses, infidelities, and creative adaptations: Lessons from evaluation of a participatory market development approach in the Andes. Evaluation and Program Planning. 2013;39:28-41.
40. Salas MA, Eusebio Abad L, Abad A, Cuellar R. Strengthening local organizations for market access: The case of coffee and cocoa cooperatives in Peru. In A. Devaux, M. Ordinola, & D. Horton (Eds.), Innovation for development: The Papa Andina experience Lima: International Potato Center. 2012;99-108.
41. Thiele G, Quirós CA, Ashby J, Hareau G, Rotondo E, López G, Paz Ybarnegaray R, Oros R, Arévalo D, Bentley J. Participatory market chain approach. In A. Devaux, M. Ordinola, & D. Horton (Eds.), Innovation for development: The Papa Andina experience Lima: International Potato Center. 2011;159-168.
42. Devaux A, Velasco C, López G, Bernet T, Ordinola M, Pico H, Thiele G, Horton D. Collective action for innovation and small farmer market access: The Papa Andina experience. CAPRi Working Paper No. 68. Washington, DC: International Food Policy Research Institute; 2007.
43. Ordinola M, Devaux A, Manrique K, Fonseca C, Thomann A. Strengthening competitiveness of the potato market chain: An experience in Peru. In A. Devaux, M. Ordinola, & D. Horton (Eds.), Innovation for development: The Papa Andina experience Lima: International Potato Center. 2011;151-160.
44. Bernet T, Devaux A, Ortiz O, Thiele G. Participatory market chain approach. BeraterInnen News. 2005;1:8-13.
45. Hall A, Bockett G, Taylor S, Sivamohan MVK, Clark N. Why research partnerships really matter: Innovation theory, institutional arrangements and implications for developing new technology for the poor. World Development. 2001;29(5):783-797.
46. Misiko M, Tittonell P, Ramisch JJ, Richards P, Giller KE. Integrating new soybean varieties for soil fertility management in smallholder systems through participatory research: Lessons from western Kenya. Agricultural Systems. 2008;97(1-2):1-12.
47. Witcombe JR, Joshi KD, Gyawali S, Musa AM, Johansen C. Virk DS, Sthapit BR. Participatory plant breeding is better described as highly client-oriented plant breeding. I. Four indicators of client-orientation in plant breeding. Experimental Agriculture. 2005;41(3):299-319.
48. Snapp SS, Blackie MJ, Gilbert RA, Bezner-Kerr R, Kanyama-Phiri GY. Biodiversity can support a greener revolution in Africa. Proceedings of the National Academy of Sciences. 2010;107(48):20840-20845.
49. Ceccarelli S, Grando S. Decentralized-participatory plant breeding: An example of demand driven research. Euphytica. 2007; 155(3):349-360.
50. Humphries S, Gallardo O, Jimenez J, Sierra F, Gallardo O, Gomez M, Barahona M, Avila R, Mendoza D, Trejo M. Opening cracks for the transgression of social boundaries: An evaluation of the gender impacts of farmer research teams in Honduras. World Development. 2012;40 (10):2078-2095.
51. Sthapit BR, Joshi KD, Witcombe JR. Farmer participatory crop improvement. III. Participatory plant breeding, a case study for rice in Nepal. Experimental Agriculture. 1996;32(4):479-496.
52. Ceccarelli S. Efficiency of plant breeding. Crop Science. 2015;55(1):87-97.
53. Mayer E, Quispe H. Integrating farmer knowledge and formal research: The challenge of participatory research in Peru. In D. Poland, L. Sawaya, & S. Birner (Eds.), Participatory and collaborative research for sustainably improved livelihoods. 2004;239-246.
54. Ashby J. The impact of participatory plant breeding. In S. Ceccarelli, E. P. Guimarães, & E. Weltzien (Eds.), Plant breeding and farmer participation Rome: Food and Agriculture Organization of the United Nations. 2009;649-671.
55. vom Brocke K, Trouche G, Weltzien E, Barro-Kondombo CP, Gozé E, Chantereau J. Participatory variety development for sorghum in Burkina Faso: Farmers'

selection and farmers' criteria. Field Crops Research. 2010;119(1):183-194.
56. Mandal MAS, Hossain M, Paris TR, Samson BB, Magor NP, Kabir KA. Empowering farmer field school: An innovative approach for enhancing sustainable rice production. In T. R. Paris & M. F. Rola-Rubzen (Eds.), Gender dimension of climate change research in agriculture: Case studies in Southeast Asia Los Baños: SEARCA. 2014;49-72.
57. Sanginga PC, Tumwine J, Lilja NK. Patterns of participation in farmers' research groups: Lessons from the highlands of southwestern Uganda. Agriculture and Human Values. 2006;23 (4):501-512.
58. Upreti BR, Upreti YG. Factors leading to agro-biodiversity loss in developing countries: The case of Nepal. Biodiversity & Conservation. 2002;11(9):1607-1621.
59. Bellon MR, Berthaud J, Smale M, Aguirre JA, Taba S, Aragón F, Díaz J, Castro H. Participatory landrace selection for on-farm conservation: An example from the Central Valleys of Oaxaca, Mexico. Genetic Resources and Crop Evolution. 2003; 50(4):401-416.
60. Mercado AR, Patindol M, Garrity DP. The landcare experience in the Philippines: Technical and institutional innovations for conservation farming. Development in Practice. 2001;11(4):495-508.
61. Wall PC. Tailoring conservation agriculture to the needs of small farmers in developing countries: An analysis of issues. Journal of Crop Improvement. 2007;19(1-2):137-155.
62. Wangui EE. Development interventions, changing livelihoods, and the making of female Maasai pastoralists. Agriculture and Human Values. 2008;25(3):365-378.
63. Bentley JW. Facts, fantasies, and failures of farmer participatory research. Agriculture and Human Values. 1994;11(2-3):140-150.
64. Erbaugh JM, Donnermeyer J, Amujal M, Kidoido M. Assessing the impact of farmer field school participation on IPM adoption in Uganda. Journal of International Agricultural and Extension Education. 2010;17(3):5-17.
65. Witcombe JR, Gyawali S, Sunwar S, Sthapit BR, Joshi KD. Participatory plant breeding is better described as highly client-oriented plant breeding. II. Optional farmer collaboration in the segregating generations. Experimental Agriculture. 2006;42(1):79-90.
66. Neef A, Neubert D. Stakeholder participation in agricultural research projects: A conceptual framework for reflection and decision-making. Agriculture and Human Values. 2011;28(2):179-194.
67. Hellin J, Bellon MR, Badstue L, Dixon J, La Rovere R. Increasing the impact of participatory research. Experimental Agriculture. 2008;44(1):81-95.
68. Kaaria S, Njuki J, Abenakyo A, Delve R, Sanginga P. Assessment of the enabling rural innovation (ERI) approach: Case studies from Malawi and Uganda. Natural Resources Forum. 2008;32(1):53-63.
69. Sultana P, Thompson P. Gender and local floodplain management institutions: A case study from Bangladesh. Journal of International Development. 2008;20(1):53-68.
70. Tapia ME, De la Torre A. Women farmers and Andean seeds. Rome: Food and Agriculture Organization of the United Nations; 1998.
71. Humphries S, Classen L, Jiménez J, Sierra F, Gallardo O, Gómez M. Opening cracks for the transgression of social boundaries: An evaluation of the gender impacts of farmer research teams in Honduras. World Development. 2012;40(10):2078-2095.
72. Galiè A, Jiggins J, Struik PC. Women's identity as farmers: A case study from ten households in Syria. NJAS-Wageningen Journal of Life Sciences. 2013;64:25-33.
73. Sumberg J, Reece D. Agricultural research through a 'new product development' lens. Experimental Agriculture. 2004;40(3):295-314.
74. Abay F, Waters-Bayer A, Bjørnstad Å. Farmers' seed management and innovation in varietal selection: Implications for barley breeding in Tigray, northern Ethiopia. Ambio: A Journal of the Human Environment. 2008;37(4):312-320.
75. Snapp S, Kanyama-Phiri G, Kamanga B, Gilbert R, Wellard K. Farmer and researcher partnerships in Malawi: Developing soil fertility technologies for the near-term and far-term. Experimental Agriculture. 2002;38(4):411-431.
76. Johnson NL, Lilja N, Ashby JA. Measuring the impact of user participation in agricultural and natural resource management research. Agricultural Systems. 2003;78(2):287-306.

77. Van Asten PJA, Kaaria S, Fermont AM, Delve RJ. Challenges and lessons when using farmer knowledge in agricultural research and development projects in Africa. Experimental Agriculture. 2009;45 (1):1-14.

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