



Social Impacts of Farmer-Led Innovation Systems on Rural Livelihoods: Evidence from the Farmer FIRST Programme in the Indian Himalayas

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Abstract

The Farmer FIRST (Farm, Innovation, Resources, Science and Technology) Programme, initiated by the Indian Council of Agricultural Research (ICAR), signifies a strategic shift towards participatory, farmer-centric innovation in India's agricultural research and extension system. This study assesses its social impacts on rural livelihoods in the mid-hill region of Uttarakhand, a fragile Himalayan context marked by smallholder farmers, outmigration, and the feminisation of agriculture. A mixed-methods approach was employed, integrating household surveys ($n = 120$), focus group discussions (9), key informant interviews (6), and secondary data collected during 2016–2025 across three villages. Social impacts were examined across five dimensions: community cohesion and inclusion, access to technology, extension services, social participation, and household welfare. Findings indicate notable improvements in technology adoption, extension access, women's participation, and perceived well-being. Women's involvement in farm decision-making increased by 47%, access to extension services rose from 34% to 87%, and 69% of households reported enhanced food security and livelihood stability. However, disparities among marginalised groups, limited financial capital, and weak market linkages constrain long-term sustainability. The study underscores the potential of participatory innovation systems in enhancing social outcomes, while highlighting the need for strengthened institutional inclusion, market integration, and rural finance to ensure enduring developmental gains.

Keywords: Farmer-led innovation; Social impact assessment; Participatory extension; Rural livelihoods; Himalayan agriculture; Gender and inclusion; Agricultural institutions.

1. Introduction

Agriculture sector continues to play a central role in rural livelihoods and food security in low- and middle-income countries, yet its developmental potential remains constrained by persistent structural challenges. In India, agriculture supports over 42% of the workforce while contributing less than one-fifth of national GDP, reflecting enduring issues related to land fragmentation, low productivity, climate variability, and uneven access to markets and institutions (Government of India, 2025). These challenges are particularly acute in North Himalayan states such as Uttarakhand, where agricultural systems are shaped by steep terrain, fragile ecosystems, pre-dominantly rain-fed and small landholdings, and limited infrastructure.

Rural transformation in ecologically fragile Himalayan regions is shaped not only by technological change but by the reinvention of social institutions, gendered authority, and collective action. The mid-hill regions of Uttarakhand state have experienced sustained outmigration, especially of men, resulting in labour shortages and the progressive feminisation of agriculture. Women increasingly manage agricultural production alongside household and natural resource responsibilities, often in the absence of adequate institutional support, extension services, or decision-making authority. These dynamics have contributed to declining productivity, land abandonment, and the erosion of local collective institutions, thereby weakening the resilience of rural livelihoods (Arya & Vasantha, 2018; Mehra & Joshi, 2022).

Conventional agricultural extension systems in India have historically relied on linear, top-down models of technology transfer, which have proven poorly suited to heterogeneous and resource-constrained environments such as mountain regions. In response, development scholarship has increasingly emphasised participatory and farmer-led innovation systems that recognise farmers as active co-producers of knowledge rather than passive recipients of externally generated technologies (Chambers et al., 2014; Pretty et al., 2018). Such approaches foreground social learning, collective action, and institutional embeddedness as central to sustainable agricultural and rural development.

Within this context, assessing the social impacts of agricultural innovation programmes becomes particularly important in ecologically fragile hill regions, where livelihood outcomes are closely intertwined with social relations, gender norms, community institutions, and natural resource governance. In such settings, the effectiveness of agricultural interventions cannot be adequately captured through productivity or income indicators alone. Outcomes related to social inclusion, access to knowledge and extension services, gendered participation in decision-making, and collective action are critical in shaping both adoption trajectories and long-term sustainability (Bronson, 2018, Negi et al., 2023).

Social impact assessment provides an analytical lens to examine how agricultural programmes reshape local institutions and power relations, particularly for women and marginalised households. By focusing on dimensions such as community cohesion, access to technology and services, and household welfare, social impact analysis helps move beyond narrow measures of success and towards a more comprehensive understanding of rural transformation. This perspective is especially relevant in hill agro-ecosystems characterised by smallholder dominance, high outmigration, and environmental vulnerability, where socially inclusive and institutionally grounded innovation systems are central to building long-term livelihood resilience.

Agricultural Innovation Systems (AIS): Conceptual Framework

This study adopts an Agricultural Innovation Systems (AIS) perspective, which conceptualises agricultural development as an outcome of dynamic interactions among diverse actors- including farmers, research institutions, extension agencies, markets, and local organisations - embedded within specific socio-economic, institutional, and ecological contexts (Hall et al., 2006). Viewed through the lens of Agricultural Innovation Systems (AIS), the Farmer FIRST programme can be understood as an institutional intervention that seeks to reconfigure interactions among farmers, researchers, extension agencies, and local organisations in order to generate socially embedded, context-specific innovation and inclusive livelihood outcomes.

This study adopts an Agricultural Innovation Systems (AIS) perspective, which conceptualises agricultural development as an outcome of dynamic interactions among diverse actors - including farmers, research institutions, extension agencies, markets, and local organisations - embedded within specific socio-economic, institutional, and ecological contexts. Rather than viewing innovation as a linear process of technology transfer, the AIS framework emphasises knowledge co-production, learning processes, and institutional arrangements that shape how innovations are generated, adapted, and sustained. From this perspective, social outcomes such as inclusion, collective action, access to services, and empowerment are not peripheral effects but integral components of innovation performance. In hill agro-ecosystems characterised by smallholder dominance, labour outmigration, and environmental vulnerability, the effectiveness of innovation systems depends critically on how well they integrate marginalised actors—particularly women—and strengthen local institutions that mediate access to resources, markets, and decision-making. Applying the AIS lens allows this study to assess Farmer FIRST not merely as a technology dissemination programme, but as an institutional intervention that reshapes actor relationships and governance structures, thereby influencing social and livelihood outcomes over time.

AIS in the Hill Agriculture Context

In fragile hill agro-ecosystems such as those of Uttarakhand, agricultural innovation unfolds under conditions markedly different from those of the plains. Fragmented landholdings, limited resource endowments, and weak physical and institutional connectivity shape both production choices and innovation pathways. These constraints are further compounded by persistent labour shortages driven by male out-migration, leading to the growing feminization of agricultural work and decision-making. At the same time, the gradual erosion of traditional collective institutions has weakened local mechanisms for coordination, risk-sharing, and mutual support.

Such conditions pose significant challenges to conventional, top-down models of agricultural extension and technology dissemination, which often assume uniform production environments, stable labour availability, and direct market linkages. From an Agricultural Innovation Systems (AIS) perspective, hill agriculture demands innovation arrangements that are institutionally grounded, socially inclusive, and territorially embedded. Innovation in these contexts is less about linear technology transfer and more about processes of experimentation, adaptation, and learning that occur at household and community levels. Knowledge circulates primarily through social learning networks, while local institutions play a critical mediating role in enabling access to inputs, services, and markets.

Importantly, women and other marginalized groups emerge as central actors within hill innovation systems, rather than passive beneficiaries. Consequently, innovation performance in hill agriculture depends less on the technical superiority of interventions and more on how effectively innovation networks reach marginalized farmers, negotiate gendered labour and decision-making structures, and strengthen collective institutions that support coordination, resilience, and long-term sustainability.

Farmer FIRST as an Institutional Intervention within AIS

Viewed through an Agricultural Innovation Systems (AIS) lens, the Farmer FIRST programme extends well beyond the introduction of new technologies or improved farm practices. It functions as an institutional intervention aimed at reshaping the relationships among farmers, researchers, and extension agencies. By foregrounding farmer participation in experimentation and knowledge generation, the programme seeks to shift innovation processes from linear technology transfer to more interactive and context-responsive pathways.

A central feature of Farmer FIRST is its emphasis on strengthening local organisations and producer groups, thereby enabling collective action and multi-actor coordination around production decisions, resource management, and market engagement. In this sense, the programme operates as a relational interface within the innovation system. It mediates how farmers articulate their needs and priorities, how research agendas are aligned with local conditions, and how learning and information flows are generated and sustained. Importantly, it also influences how innovations are adapted, shared, and eventually institutionalised within local farming systems.

From this perspective, the outcomes of the Farmer FIRST programme cannot be assessed solely in terms of technology adoption or productivity gains. Rather, its effectiveness lies in the extent to which it enhances the inclusion of marginal and migrant households, expands women's participation and decision-making space, improves access to services and knowledge networks, revitalises group-based and collective arrangements, and ultimately strengthens local innovation capability. Such institutional outcomes are critical for building resilient and adaptive agricultural systems.

Social Outcomes as Core Components of Innovation Performance

Within Agricultural Innovation Systems (AIS) scholarship, innovation is understood as a fundamentally social and institutional process rather than a purely technical one. Consequently, outcomes such as social inclusion and equity of participation, trust and reciprocity, collective action, empowerment and agency, institutional strengthening, and access to knowledge and extension services are not peripheral social benefits or unintended programme effects. Instead, they constitute core dimensions of innovation performance itself.

In mid-hill agricultural systems, where livelihoods are shaped by persistent out-migration, gendered transitions in labour and decision-making, and heightened environmental vulnerability, these social and institutional outcomes play a decisive role in shaping innovation trajectories. They influence whether new technologies are meaningfully used, locally adapted, or ultimately abandoned; how knowledge circulates within and across farmer networks; and whether innovation processes remain individualised or evolve into collective practices. Over time, these dynamics also determine the durability and sustainability of livelihood gains.

From this perspective, AIS provides an analytical framework in which social impact is not treated as an “add-on” to technical innovation, but as a structural determinant of innovation sustainability. Recognising social processes as integral to innovation outcomes is therefore essential for understanding how and why agricultural interventions succeed or fail in complex and resource-constrained contexts.

Agricultural Innovation Systems (AIS): Conceptual Framework

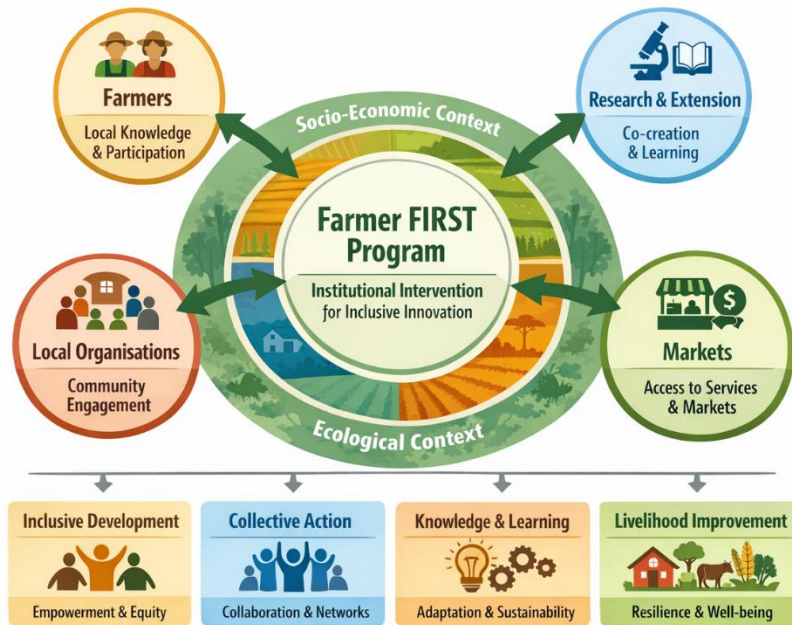


Fig. 1: Conceptual framework of FFP implementation

The above conceptual framework views agricultural development as the outcome of dynamic interactions among multiple actors - farmers, research and extension agencies, local organisations, and markets - operating within specific socio-economic and ecological contexts. Rather than treating innovation as a linear process of technology transfer, the framework emphasises knowledge co-production, collective learning, and institutional arrangements that shape how innovations are generated, adapted, and sustained. Social dimensions such as inclusion, empowerment, and collective action are considered integral to innovation performance, not peripheral outcomes.

Within this framework, the Farmer FIRST Programme is conceptualised as an institutional intervention that reconfigures relationships among key actors to foster context-specific, socially embedded innovations. Particularly in hill agro-ecosystems characterised by smallholder farming and environmental vulnerability, the programme's effectiveness depends on integrating marginalised groups—especially women—and strengthening local institutions. Through improved collaboration, access to services and markets, and strengthened governance structures, the system ultimately contributes to inclusive development, livelihood improvement, and long-term resilience.

2. Objectives of the Study

Guided by an Agricultural Innovation Systems perspective, this study examines how farmer-led innovation processes under the Farmer FIRST programme influence social and institutional outcomes in hill agriculture. Specifically, the study aims to:

1. **Assess changes in social inclusion and community cohesion** associated with farmer participation in local innovation platforms and collective learning processes;
2. **Examine shifts in farmers' access to agricultural technologies and extension services**, with particular attention to the role of participatory interactions between farmers, researchers, and extension actors;
3. **Analyse changes in social participation and household welfare outcomes**, including gendered decision-making, access to welfare schemes, and perceived livelihood resilience, resulting from the reconfiguration of local innovation and support systems.

Scope of the Study

This study addresses an important empirical gap by examining the social and institutional impacts of the Farmer FIRST programme implemented between 2016 and 2025 in three mid-hill project villages of Nainital district - Dogra, Syalikhhet, and Jeoli – in Uttarakhand. Anchored in an Agricultural Innovation Systems perspective, the analysis extends beyond technology adoption to assess how farmer-led innovation processes influence social relations, institutional access, and livelihood outcomes over time.

The scope of the study encompasses five interrelated dimensions of social impact:

- i. **Community Impact**, focusing on changes in social inclusion and community cohesion resulting from collective learning and interaction;
- ii. **Access to Technology**, examining adoption and use of context-specific innovations in vegetable production, backyard poultry, and beekeeping;
- iii. **Access to Extension Services**, assessing changes in farmers' access to training and advisory support, as well as the quality and relevance of engagement;
- iv. **Social Participation**, analysing participation in Self-Help Groups (SHGs), Farmer Producer Organisations (FPOs), and decision-making processes, with particular attention to gendered roles; and
- v. **Social Welfare**, evaluating changes in perceived well-being, food security, income stability, and access to social welfare schemes.

By critically examining these dimensions, the study provides empirical evidence on the extent to which participatory, farmer-centric innovation systems contribute to socially inclusive livelihood resilience in hill agriculture contexts, offering insights relevant to mountain regions and other ecologically fragile rural settings.

3. Methodology

3.1 Research Design

This study employed a descriptive research design combined with a mixed-methods approach to comprehensively assess the social impact of Farmer FIRST interventions. The mixed-methods strategy was chosen to integrate quantitative insights on measurable outcomes with qualitative narratives that capture nuanced community perceptions and experiences. Quantitative data were collected through structured household surveys, while qualitative data came from focus group discussions (FGDs), key informant interviews (KIIs), and participatory rural appraisal (PRA) techniques such as social mapping and timeline exercises. This triangulation of methods ensured robustness and validity of findings (Creswell & Plano Clark, 2018).

3.2 Study Area

The research was conducted in three project villages (**Dogra, Syalikhhet, and Jeoli**) located in Nainital district, Uttarakhand. These villages are situated in the middle Himalayan zone at altitudes ranging from 1,200 to 1,800 meters above sea level. The area experiences a temperate climate with annual rainfall averaging 1,200 mm, predominantly during the monsoon season (June–September). Agriculture is rain-fed and highly vulnerable to climatic variability. Together, the three villages account for approximately **465 households** with a total population of around 2,450 people (Census of India, 2011; updated estimates from Panchayat records, 2023). The majority of households (78%) belong to small and marginal farmer categories, holding less than 1 hectare of land. Livelihoods are primarily based on subsistence agriculture and livestock rearing, with seasonal migration contributing to household incomes. Farmer FIRST interventions in these villages included the introduction of vegetable cultivation modules, backyard poultry units, beekeeping, and ICT-enabled extension services.

Table-1: Details of population living in study area

S. No.	Village	Total Households	Population	Primary Occupation
1.	Dogra	150	820	Agriculture, Horticulture
2.	Syalikhhet	165	890	Livestock, Vegetable farming
3.	Jeoli	150	775	Mixed farming

3.3 Sampling Procedure and Sample Size

A multistage purposive sampling technique was employed. In the first stage, Nainital district was selected due to its active Farmer FIRST implementation. In the second stage, three project villages (Dogra, Syalikhhet, and Jeoli) were chosen based on their representation of mid-hill agro-ecological conditions and varied intervention profiles. A total of 120 households were sampled for quantitative surveys, distributed equally across the three villages (n=40 per village). Households were selected using systematic random sampling from beneficiary lists provided by Gram Pradhan (head of the village) to ensure representation of all intervention modules. The selected households represent diverse levels of participation across Farmer FIRST interventions, enabling analysis of differential social impacts across community cohesion, technology access, extension engagement, participation, and welfare outcomes.

3.4 Data Collection Tools and Techniques

To ensure conceptual consistency, data collection tools were explicitly structured around the five interrelated dimensions of social impact identified in the study scope. Quantitative data were gathered using a structured Interview schedule covering five domains:

1. Community impact (social inclusion, cohesiveness)
2. Access to technology (technology related to vegetable production, poultry production, beekeeping and processing of agricultural produce, honey and its by-products)
3. Access to extension services (contact frequency, training participation)
4. Social participation (SHG membership, decision-making roles)
5. Social welfare (income, food security, perceived well-being).

The Interview schedule was pre-tested in a neighboring non-sample village and refined for clarity and cultural appropriateness.

Further, qualitative data collection involved:

1. **6 Focus Group Discussions (2 per village):** Each with 8–12 participants including women, youth, and marginal farmers.
2. **9 Key Informant Interviews:** Conducted with Farmer FIRST coordinators, progressive farmers, and Panchayat leaders.
3. **Participatory Rural Appraisal (PRA):** Social mapping and historical timelines to trace changes in community dynamics pre- and post-intervention.

3.5 Data Analysis

Quantitative data were analyzed using descriptive statistics (frequencies, percentages, means) and visualized through tables and graphs. Comparative analysis was conducted to assess changes between baseline (2016) and current (2025) levels. Descriptive statistics, paired t-tests for pre/post comparisons and thematic analysis for qualitative insights. Qualitative data were thematically analyzed to identify recurring patterns and triangulate with survey findings.

3.6 Data Collection

- **Primary Data:** Household survey (n=120; 40 per village), 6 focus group discussions, 9 key informant interviews with progressive farmers and ICAR-KVK officials.
- **Secondary Data:** ICAR Farmer FIRST annual reports (2016–2025), district agriculture records, and census data.

4. Results and Discussion:

Under the “Farmer FIRST Programme” implemented since 2016, a total of five indicators of social impact were considered in the study area.

1. Community Impact

This dimension focuses on evaluating the extent of **social inclusion** and **social cohesiveness** fostered through Farmer FIRST interventions. Social inclusion refers to the active involvement of marginalized groups—including women, landless laborers, and smallholders—in program activities, decision-making processes, and access to resources. Social cohesiveness measures the strength of community bonds, collective problem-solving, and the formation or revitalization of community-based organizations (e.g., Self-Help Groups, Farmer Interest Groups). Indicators include changes in community solidarity, mutual support networks, and conflict resolution practices pre- and post-intervention.

2. Access to technology

This indicator assesses the degree of adoption and utilization of innovative technologies introduced under Farmer FIRST. Key technologies include vegetable cultivation modules, backyard poultry units, and apiculture (beekeeping). Metrics involve the percentage of households adopting these practices, continuity of use over time, and perceived relevance and benefits. It also explores enabling and constraining factors affecting technology adoption, such as affordability, gender roles, and compatibility with existing farming systems.

3. Access to Extension services

This component evaluates the frequency, quality, and relevance of farmer engagement with extension personnel, training programs, and information dissemination platforms. It considers the number of contacts farmers have had with extension agents, participation in training sessions, field demonstrations, and use of ICT-based advisories. Quality indicators include farmer satisfaction with the support received, timeliness of advisory services, and the extent to which farmers apply acquired knowledge and skills in their farming practices.

4. Social Participation

This dimension captures the involvement of community members in collective action and institutional processes facilitated by the program. It includes participation in Self-Help Groups (SHGs), Farmer Producer Organizations (FPOs), community meetings, and decision-making forums. Special attention is given to gendered participation—whether women and youth are adequately represented and have agency in shaping local development initiatives. The indicator also examines whether participatory spaces created during the intervention have strengthened or weakened over time.

5. Social Welfare

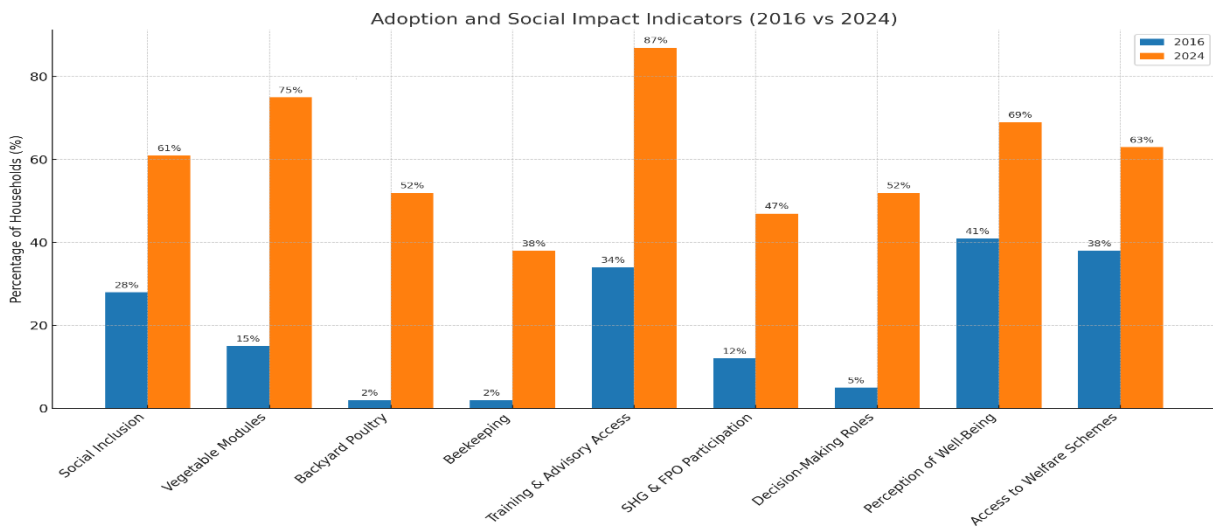
This indicator measures changes in perceived and objective well-being among participating households. It covers access to welfare schemes (e.g., subsidies, insurance, health and education benefits), improvements in household food security, income stability, and quality of life. Subjective well-being is assessed through farmer perceptions of changes in household resilience, satisfaction with livelihood outcomes, and aspirations for the future. Objective metrics include increased enrollment in government welfare programs and reduced vulnerability to socio-economic shocks.

Table-2. Social impact of Farmer FIRST Programme in the study area (n=120)

1. COMMUNITY IMPACT			
Indicator	(i). Social Inclusion		(ii). Social Cohesiveness
Key Findings (2016)	28% participation of marginalized groups (women, SC/ST). Only 3% of SHGs were women-led. Youth and SC/ST involvement in community meetings was <10%.		Community engagement limited. 62% of respondents reported frequent inter-group conflicts and lack of trust among farmer groups.
Key Findings (2025)	61% participation of marginalized groups. Formation of 3 new women-led SHGs and 2 youth groups. Women now comprise 45% of farmer meetings attendees.		Farmer Field Schools and collective training improved trust and mutual support. 48% reported reduced conflicts; 65% reported stronger neighbor networks.
Change (%)	+33%		Qualitative improvement
2. ACCESS TO TECHNOLOGY			
Indicator	i. Vegetable Production	ii. Backyard Poultry	iii. Beekeeping
Key Findings (2016)	15% of households practiced kitchen gardening; mostly traditional varieties with low productivity.	Not practiced widely; only 2 households had local breeds for home consumption.	Practiced by 3 households (2%); low honey yields due to poor equipment and training.
Key Findings (2025)	75% adopted vegetable cultivation modules with high-yield seeds, drip irrigation, and crop rotation. 72% reported increased vegetable consumption.	52% households adopted improved backyard poultry units. Average income per household from poultry rose by ₹12,000/year.	38% adopted modern beekeeping with box hives. Average honey production per household: 14 kg/year. 60% reported selling surplus honey locally.
Change (%)	+60%	+52%	+35%
3. ACCESS TO EXTENSION SERVICES			
Indicator	i. Training & Advisory Access		ii. Quality of Engagement
Key Findings (2016)	Only 34% of farmers accessed extension annually (avg. 1–2 visits/year). 78% expressed dissatisfaction with relevance of advice.		Irregular extension visits. Generic, top-down advisories with limited relevance to hill farming systems.
Key Findings (2025)	87% of farmers engaged in extension services (avg. 6–8 interactions/year). 82% expressed satisfaction with timely, tailored advisories.		Regular, participatory engagement. Use of ICT tools (mobile apps, WhatsApp groups) reached 64% of farmers. 72% praised context-specific solutions.
Change (%)	+53%		Significant improvement
4. SOCIAL PARTICIPATION			
Indicator	i. SHG and FPO Participation		ii. Decision-Making Roles
Key Findings (2016)	Only 12% households involved in SHGs/FPOs. Female membership was 7%.		Women rarely consulted; only 5% reported involvement in farm decisions.
Key Findings (2025)	47% active in SHGs/FPOs. 65% of SHGs now women-dominated. FPO initiated collective vegetable marketing benefiting 80 households.		Women's involvement in farm and community decisions rose to 52%. 3 women leaders elected in village-level Farmer Interest Groups.
Change (%)	+35%		+47%

5. SOCIAL WELFARE		
Indicator	i. Perception of Well-Being	ii. Access to Welfare Schemes
Key Findings (2016)	41% felt “satisfied” with livelihoods; frequent food insecurity reported by 38% of households.	38% enrolled in government schemes (e.g., PM-Kisan, crop insurance).
Key Findings (2025)	69% reported “improved well-being.” Food insecurity reduced to 14% of households. Average household income rose by 23%.	63% enrolled in welfare programs. Farmer FIRST facilitators linked households to subsidies for polyhouses, poultry units, and health insurance.
Change (%)	+28%	+25%

Fig. - 2: A comparative status of key social impact indicators



The above graphic (Fig.-2) illustrates the comparative status of key social impact indicators in the target villages of Nainital district before (2016) and after (2025) the implementation of the Farmer FIRST program. Nine sub-dimensions across five indicators - Community Impact, Access to Technology, Access to Extension Services, Social Participation, and Social Welfare - are represented. The graph clearly shows substantial improvements across all dimensions:

- **Community Impact:** Participation of marginalized groups, including women and Scheduled Castes from 28% in 2016 to 61% in 2025. Social cohesiveness also improved qualitatively, with 48% of respondents reporting reduced inter-group conflicts.
- **Access to Technology:** Adoption of vegetable cultivation modules increased dramatically from 15% to 75%, backyard poultry from negligible levels to 52%, and beekeeping from 2% to 38%.
- **Access to Extension Services:** Farmers accessing training and advisory services rose from 34% to 87%, while 72% reported satisfaction with the quality of engagement post-intervention.
- **Social Participation:** The proportion of households involved in SHGs and Farmer Producer Organizations (FPOs) increased from 12% to 47%, and women’s involvement in decision-making roles rose by 47%.
- **Social Welfare:** Households perceiving improved well-being grew from 41% to 69%, and enrollment in welfare schemes expanded from 38% to 63%.

These trends indicate that Farmer FIRST interventions have been successful in enhancing technology adoption, community engagement, and welfare outcomes. However, variability in adoption rates across technologies suggests the need for customized capacity-building and market support mechanisms.

5. Discussion: Interpreting Social Impacts through an AIS Framework

5.1 Reconfiguring Actors and Inclusion within the Innovation System

From an AIS perspective, the observed improvements in social inclusion and community cohesion reflect a broadening of actor participation within local innovation systems. Farmer FIRST interventions created spaces for women, youth, and marginalised farmers to engage directly with researchers, extension agents, and local institutions. These interactions altered traditional power asymmetries by positioning farmers - particularly women - not merely as technology recipients but as active contributors to innovation processes. Similar patterns have been documented in participatory innovation

systems in other fragile agro-ecological contexts (Pretty et al., 2018; FAO, 2023). It is also consistent with core AIS scholarship that emphasises interaction, learning, and institutional change as central to innovation performance (Hall et al., 2006).

5.2 Strengthening Interactions and Learning Processes

Enhanced access to technologies and extension services illustrates the central role of interaction and learning within effective innovation systems. Regular farmer–scientist engagements, field demonstrations, and ICT-enabled advisory platforms facilitated iterative learning and adaptation of technologies to local conditions. The differential adoption rates across enterprises, especially lower uptake of beekeeping, underscore that learning alone is insufficient without complementary support related to finance and markets. This finding reinforces AIS literature emphasising the importance of coordinated support functions beyond knowledge dissemination.

5.3 Institutional Change and Collective Action

The expansion of SHGs, Farmer Interest Groups, and FPOs reflects institutional strengthening within the local innovation system. These organisations served as intermediaries linking farmers to inputs, extension services, and welfare schemes, while also fostering collective action and social accountability. Increased participation of women in decision-making roles suggests gradual shifts in informal institutions governing gender relations. However, the uneven participation of marginalised households indicates that institutional inclusion remains a work in progress.

5.4 Livelihood Outcomes as System-Level Effects

Improvements in household welfare, food security, and income stability can be interpreted as system-level outcomes emerging from cumulative changes in actors, interactions, and institutions. Rather than being attributable to single technologies, these outcomes reflect the synergistic effects of improved access to knowledge, collective platforms, and institutional linkages. This reinforces the AIS argument that sustainable livelihood gains arise from systemic transformation rather than isolated interventions.

5.5 Implications for Farm Innovation Policy in Hill Agriculture

The findings suggest that participatory, farmer-led innovation systems such as Farmer FIRST can generate significant social and institutional benefits in hill agriculture contexts. However, the persistence of constraints related to credit access and market integration highlights the limits of innovation programmes operating in isolation. For AIS-based interventions to achieve sustained impact, they must be embedded within broader rural development strategies that address financial inclusion, value chain development, and infrastructural gaps, particularly in ecologically fragile regions.

6. Conclusion

The Farmer FIRST (Farmers’ Farm, Innovation, Resources, Science, and Technology) program has brought about transformative social change in the hill villages of Nainital district over the period 2016–2025. The program’s participatory approach effectively shifted the extension paradigm from a researcher-centric to a farmer-centric model, fostering inclusive innovation and strengthening community resilience. Key outcomes include a remarkable rise in the participation of marginalized groups, notably women and Scheduled Castes, from 28% to 61%, alongside the formation of new women-led Self-Help Groups (SHGs) and youth collectives. The program’s emphasis on technology transfer resulted in widespread adoption of vegetable cultivation modules, backyard poultry, and beekeeping, enhancing household nutrition and diversifying incomes. Similarly, improved access to extension services—through regular field visits and ICT tools—empowered farmers with timely, context-specific advisories. This contributed not only to increased productivity but also to social cohesiveness, with Farmer Field Schools and community events fostering stronger interpersonal networks and reducing inter-group conflicts. However, certain structural and operational challenges remain. The uneven adoption of technologies, particularly beekeeping, highlights the need for tailored training and support systems. Limited access to institutional credit and underdeveloped market linkages continue to hinder the scaling-up of innovations and sustained livelihood improvements. To ensure the long-term sustainability and equity of these gains, future interventions should focus on strengthening Farmer Producer Organizations (FPOs), enhancing financial inclusion, and building robust value chains for farm produce. Scaling such participatory models across similar agro-ecological contexts could play a pivotal role in realizing rural transformation under India’s national agricultural development agenda.

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