Discussion Paper

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Abstract

Integrated Soil Fertility Management (ISFM) is a set of practices that includes the integration of fertilizer, organic inputs, and improved crop varieties, together with the knowledge, decision-making, and adaptative capacities of farmers. The adoption and associated gain derived from ISFM can be enhanced if it is implemented in inclusive and gender-responsive ways. This discussion paper sheds light on how women and socially marginalized populations can benefit from ISFM, using case studies from Nepal, and suggests a gender-responsive ISFM framework for broader applicability.

Keywords: Gender, integrated soil fertility management (ISFM), fertilizer, inclusion, Nepal

Acknowledgment

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Definitions

Gender: A complex system of roles, expressions, identities, performances, and qualities given meaning by society to an individual based on that person being a man or a woman. It is the socially and culturally constructed conception of what it means to be a man or a woman in a particular society or context.

Social inclusion: The process of improving the terms on which individuals and groups participate in society — improving the abilities, opportunities, and dignity of those disadvantaged based on their identity, and the removal of institutional barriers and enhancement of incentives to increase the access of diverse individuals and groups to development opportunities.

Gender norms: Social principles that govern the behavior of girls, boys, women, and men in society and restrict their conduct to what is perceived as appropriate for their gender identity. Gender norms are neither static nor universal and change over time. Some norms are positive, for example, the norm that dictates that children shouldn't smoke. Other norms lead to inequality, for example, the one that associates men with authority and control over resources, and women with submission and reproduction. Gender norms can promote (or hinder) the ability of women and men to maximize their opportunities to participate in production, consumption, and benefit-sharing in agri-food systems.

Gender roles: Behaviors, attitudes, and actions that society feels are appropriate or inappropriate for a man or woman, boy or girl, according to cultural norms and traditions.

Gender gap: A disparity between men's and women's position in a society based on gender norms and expectations.

Gender-responsive: Outcomes that reflect an understanding of gender roles and inequalities, and which try to encourage equal participation and an equal and fair distribution of benefits.

Gender-transformative: Programs and interventions that create opportunities for individuals to actively challenge gender norms, promote positions of social and political influence for women in communities, and address power inequities between persons of different genders.

Preface

With the increasing global population and the growing demand for healthy and culturally appropriate food, it is important to reassess the prevalent global agrifood systems, especially in the face of the increasing fertilizer crisis, and farmers unable to obtain quality fertilizer at the time they need it. The ongoing fertilizer crisis is further exacerbated by the imbalanced application and unequal distribution of fertilizers. Integrated soil fertility management (ISFM) can be effective in providing balanced nutrients, maintaining soil health and increasing crop productivity. ISFM technologies can reduce market dependency and facilitate the use of local resources and the traditional knowledge of men and women farmers.

The Sustainable Agrifood Systems (SAS) program at CIMMYT generates social and agricultural innovations and cutting-edge agricultural technologies, and has an abiding commitment to sustainable, inclusive approaches to agricultural research for development. The prevailing biases faced in agriculture by youth and women, along with minorities and aging agricultural populations, are constraints to resilient and equitable development.

A foundation for SAS is equitable access to quality fertilizer that addresses the needs and preferences of farming communities. These include women, youths, and marginalized farmers, who seek means to increase productivity and adapt to climate change, for equitable and inclusive development that reduces the number of destitute people through increasing access to ample and nutritious food. Even if fertilizer management does not seem to be gendered at first glance, this paper highlights the need for ISFM to follow a more gender-responsive approach in smallholder farming to derive the maximum benefit from it. The paper recommends more context-specific, tailored solutions so that the diverse end-users can benefit equitably.

The framework suggested in this paper focuses on the three action areas relevant for soil fertility management: research (fertilizer trials), extension (training, service provision, on-farm demonstrations, farmers' field days), and practice (adoption of appropriate fertilizer management practices). To achieve gender-responsive results, and advances in other gender and social inclusion (GESI) outcomes, the framework suggests five decision points (existing gaps/needs, user profiles, users' selection criteria, GESI constraints, monitoring and learning) and the corresponding information required for GESI-responsiveness, as suggestions to implement the framework.

Sieglinde Snapp

Director, Sustainable Agrifood Systems Program (SAS)

1. Introduction

About 74% of Nepalese women are engaged in agriculture, compared to 51% of men. Given that they work chiefly as subsistence producers, the employment conditions of most rural women continue to be perilous. Gender gaps in technology adoption constrain women's empowerment, farm productivity, food security, and family welfare. Paudel et al. (2020) report that, with an equal level of access to resources, women's likelihood of adopting new agricultural technology would increase by 5%. FAO posited that closing the gender gap would increase global yields by 20–30%, agricultural outputs by 2.5–4%, and reduce the number of hungry people by 12–17% (FAO 2011). The same FAO report states that rural women can spend up to four hours a day walking to collect fuel and water. Considering women's role in agriculture and soil fertility management, they should be involved in research and demonstration plots of fertilizer trials. However, their work burden and their limited control over their own land, labor, and mobility hinder their participation in hosting demonstration plots or receiving training and extension services. Moreover, other intersectionality issues such as proximity, poverty, age, and education are also important to consider as gender and social inclusion matters in designing a gender-responsive integrated soil fertility management system.

Men and women farmers play different roles in agrifood systems, possess different levels of knowledge about them, and exert different capacities to understand, adopt, and benefit from agricultural technology, including management practices. The differences between female and male farmers are largely due to the prevalent social and gender norms, which comprise socially constructed beliefs and practices that associate men with authority and control over resources and women with submission and reproduction (Petesch and Badstue 2019). Gender norms may lead to women's under-representation in training and extension, as farmers are often believed to be men, but not women, due to the "conceptual lock-in" mindset of rural advisory and extension services in developing countries, which means thinking of farmers as men, regardless of the reality of female farmers on the ground (Farnworth and Colverson 2015). For agricultural innovations and technologies to reach end-users equitably and create an enabling environment for the effective participation of both men and women in agriculture, researchers and policymakers need to think holistically and systemically about agricultural innovation. Using a case study from Nepal, this paper focuses on Integrated Soil Fertility Management (ISFM) and discusses the pathways for inclusive ISFM research, extension, and practices in developing countries.

ISFM is a set of soil fertility management practices that includes the use of synthetic and organic fertilizers and chemicals for pest and disease control, combined with improved crop varieties and knowledge about how to adapt these to local conditions; it aims to improve crop productivity and the efficiency of inputs, managing the latter according to sound agronomic and economic principles (Vanlauwe et al. 2010).

In recent years, gender has been gaining attention and has been discussed in the literature under different dimensions of agricultural research for development (AR4D). Gender — the socially and culturally constructed ideas about what it means to be a man or a woman in a particular society or context — is an important domain in AR4D that determines equity and opportunity to participate in agricultural mainstreaming, and also to benefit from agricultural innovations and services. Culturally, some groups, including men, rich, and resourceful farmers, are more privileged than others who are less fortunate as regards access and opportunity, such as women, the poor, and marginalized communities. However, bringing these underprivileged groups into the mainstream and empowering women have the potential to increase household incomes, farm productivity, and food security, with even broader beneficial economic spillovers. For example, Paudel et al. (2020) discuss how mechanization can be gendered, by analyzing the scenario of resource access switching from men to women, and thereby enhancing the adoption of mini-tillers in maize cultivation. Another body of literature addresses cases across the developing world where working-age men seek off-farm employment, often migrating to cities or other countries and leaving women to manage farm homesteads (Gartaula et al. 2010; Pattnaik et al. 2018; Farnworth et al. 2018). This so-called "feminization" of agriculture involves overcoming special challenges to ensure the meaningful participation of women in agricultural decision-making, along with taking an

increased role in farm labor (Farnworth et al. 2021). Other studies in seed systems (Mangheni et al. 2019; Thiele et al. 2020), plant breeding (Badstue et al. 2020, 2022; Tegbaru et al. 2020), pest management (Kawarazuka et al. 2020; Ochago 2018), and agriculture-induced climate change (Farnworth et al. 2017; Murage et al. 2015; Gartaula et al. 2020) have applied gender perspectives in their analyses, but gender-based analysis has not been much used in soil fertility management studies. This may be in part because (1) soil fertility management is considered highly technical, with relatively few social dimensions; (2) nearly all fertilizer in Nepal is imported, which represents a million-dollar business; and especially (3) due to ignorance regarding women's actual and significant role in soil fertility management. Additionally, farmer cooperatives prioritize the distribution of fertilizer to members who, in most cases, are men (Neupane et al. 2022). Some studies, primarily in Africa, have looked at the interaction between gender and soil fertility management (Tsegaye et al. 2018).

Even though women play an indispensable role in agriculture and are responsible for some 60–80% of production in developing countries (FAO 2011), the conventional preconception of farmers as men undermines women's role. To reduce this bias in perception, agricultural research and extension programs and policies need to understand the socioeconomic and cultural backgrounds in which farming takes place. The needs and preferences of the diverse beneficiaries (be they women, poor, or marginalized) should be addressed in the process of designing and implementing agricultural innovations; this will help in delivering the benefits of agricultural innovations equitably and inclusively. Even through improving soil fertility is a natural and slow process, and resource-poor farmers in particular have limited affordability to wait for soils to recover, ISFM best practices can increase agricultural productivity in the long term. However, the adoption of these practices, particularly by women and farmers from marginalized groups, as well as the equitable distribution of ISFM benefits, depend on extension program designs that take into account prevalent social and gender norms and opportunity structures, which are generally biased towards men and rich farmers. Access to and control over inputs and resources to apply ISFM practices are critical in determining the equitable sharing of benefits among men and women farmers, rich and poor farmers, and those who are marginalized due to geographic, income and other social markers.

As with all agronomic alternatives, ISFM is site- and context-specific; there are no "one-size-fits-all" solutions. For example, the type of fertilizer required depends on essential plant nutrient requirements for specific soils and crops and even for the crop yields sought. If nitrogen is the only nutrient lacking, the farmer may apply only urea. If phosphorus and micro-nutrients are lacking, the farmer may apply customized blended fertilizers containing phosphorus and micronutrients. The quantity to apply will depend on the soil test results and will differ from one field to another. The kind of organic inputs to apply will depend on which materials are locally available. They may be crop residues, manure, compost, or a combination of materials. Similarly, the adoption of improved germ¬plasm will depend on the high-yielding crop varieties developed and recommended for a particular agro-ecological region, and access to and availability of the technology for different types of farmers. At the same time, even if they may be available, the opportunities and capacities of men and women farmers to purchase may differ.

This discussion paper sheds light on these critical elements of soil fertility management and suggests how women and marginalized farmers could benefit from ISFM interventions. The case used for analysis is from a USAID-funded Feed the Future Nepal Seed and Fertilizer (NSAF) project led by the International Maize and Wheat Improvement Centre (CIMMYT). The project contributes to overcoming socioeconomic and cultural barriers to gender- and socially-inclusive ISFM research, extension, and practices in the project areas in Nepal.

The Nepal Seed and Fertilizer Project

Led by CIMMYT and implemented from April 2016 to December 2002 with funding from the US Agency for International Development (USAID), the Nepal Seed and Fertilizer (NSAF) project has sought to strengthen Nepal's seed and fertilizer systems by:

- Enhancing the capacity and role of public, private, and community sectors in the seed and fertilizer value chains through the provision of technical and business development services;
- Improving private sector access to inbred lines, new fertilizer products and research knowledge from national and international research institutions for commercializing agriculture; and
- Enhancing public-private partnerships and coordination for scaling seed and soil management-related innovations.

The work contributes to USAID's Feed the Future goal of sustainably reducing global poverty and hunger, in alignment with the Feed the Future Nepal multi-year (2011–2017) strategy and USAID's Country Development Cooperation Strategy for Nepal (2020-25).

2. Integrated soil fertility management in Nepal

Gender-responsive ISFM lies in understanding the socio-technical dimensions of soil fertility management in which farmers' livelihoods and the fertilizer market interact. The technical features of soil fertility, fertilizer use, and crop management are one aspect of this; access to and control over resources to manage such technical features are equally important for technical solutions to reach the underserved.

2.1. Fertility management practices in Nepal

In Nepal, fertilizer doses for crops are given as blanket recommendations; i.e., in uniform rates of nitrogen (N), phosphorus (P), and potassium (K) across agroecological zones without considering variations in climate, soil types, cropping systems, or crop management. Moreover, many fertilizer recommendations were developed during the 1970s (Joshi and Deo 1976) and do not make much sense in today's changing soil and weather conditions, especially under recent and unprecedented climate variations. Likewise, farmers do not follow the recommended rates and apply relatively higher amounts of N, lower-to-medium P, and very low-to-negligible amounts of K, leading to significant gaps between actual and potential yields (Devkota et al. 2018). The imbalanced use of fertilizers followed by inefficient and inappropriate crop management practices have heightened nutrient losses to the environment and reduced fertilizer-use efficiency (Chen et al. 2020), which again reduce crop yields and the value of households' fertilizer purchases.

In general, farmers apply lower quantities of mineral fertilizers than the recommended dose, although fertilizer use varies by agroecology, being much higher in the Terai, Nepal's large lowland breadbasket in the south, compared to the mid-hill and mountain regions. Farmers typically apply around one-third of the recommended fertilizer dose on wheat, maize, and mustard crops (Devkota et al. 2018). According to the survey of farmers' nutrient management practices conducted by NSAF across five districts (Kavre, Palpa, Dang, Surkhet, and Doti), the average use of inorganic fertilizers in maize followed the order of N > P > K, and was 30% less than the recommended rate (120:60:40 kg NPK/ha). In rice, the use of inorganic fertilizers by farmers in four surveyed districts of the Terai (Banke, Bardiya, Kalali, and Kanchanpur) was 80% lower for N, 10–60% lower for K, and more or less similar for P compared to the recommended NPK rate. Reported results also showed wide variation, reflecting the imbalanced use of fertilizers among farmers in each district. In contrast, a study conducted by Haefele et al. (2014) reported the consistent use of inorganic fertilizers in both the mid-hill (Lamjung) and Terai (Chitwan) districts, following the sequence of N > P > K.

There is little research or extension on fertilizer in Nepal. The Nepal Agricultural Research Council (NARC) conducts yearly, long-term fertility trials on their mid-hill and Terai research stations for crops such as rice, wheat, and maize, with a particular focus on major plant nutrients (NPK). This type of study helps to identify limiting nutrients and determine the optimum rates for each to maintain long-term soil fertility for specific locations and soil types. Recently, NARC has begun research on different fertilizer types and application methods to increase nitrogen use efficiency. A recent study conducted by Baral et al. (2021) reported that real-time fertilizer applications using leaf color charts and GreenSeeker optical sensors to determine timing and dosages more precisely could increase nitrogen use efficiency and crop productivity. In addition, academicians and research scholars from different organizations (public and private) have carried out some fertilizer trials, which are mainly confined to controlled greenhouse/tunnel conditions.

In contrast, on-farm soil fertility and fertilizer management studies are lacking and are crucial to identify the effects of fertilizers and their interactions with soil type, climatic conditions, management practices, and other biotic and abiotic factors. On-farm studies would be more representative than on-station trials and woud increase farmers' practical knowledge regarding soil fertility and nutrient management practices. With that aim, a mobile van soil-testing program was introduced by the Soil Management Directorate, Ministry of Agriculture and Livestock Development (MoALD), Harihar Bhawan, to measure pH, organic matter, total N, and available P and K (Pandey et al. 2018). Farmers were provided

with soil health reports and fertilizer recommendations (rate and type) for each crop at specific locations based on analyzed soil fertility status. These studies did not provide gender-disaggregated findings, treating farmers as a homogenous category which, in the eyes of traditional research and extension systems, consists of men, nor did they divide results by age, class, poverty level, or caste/ethnicity.

2.3. Gender and social inclusion challenges for ISFM in Nepal

Access to and adoption of improved varieties, water, and agricultural inputs are influenced by poverty, gender, property rights, market distribution systems, education, and access to credit, markets, finance, extension services, and technology. Female farmers and disadvantaged groups such as the Dalit and Janajati face constraints to engaging in adoption decisions regarding improved technologies and innovation systems. Multiple factors intersect to pose barriers to the knowledge of, access to, participation in, and adoption of technology in the value chain by women and disadvantaged groups.

Agricultural mechanization is not common in Nepal; most farming operations are manual and depend on intra-household labor. ISFM practices involve all household members, with varying opportunities for participation and empowerment.

The NSAF baseline study reports both gender-responsive and gender-neutral challenges of fertilizer management in Nepal in general, but particularly in the NSAF project areas. The geographic differences between the hills and Terai could be an example of gender-neutral challenges that face men and women farmers equally. The report highlights poor knowledge of ISFM and of nutrient deficiency symptoms in crops. However, there was not much difference between men and women in degrees of knowledge. When questioned on whether male or female household members were more likely to attend training on seeds or soil fertility, more male respondents mentioned female members and, conversely, more female respondents said that male members were more likely to attend training (CIMMYT, 2020).

Even though access to resources by male and female heads of households is not always straightforward, the literature shows that adoption of improved varieties and technologies, including improved soil fertility management, is gendered (Polar et al. 2021). A study conducted in the central mid-hills of Nepal showed that women provided more labor for plowing, sowing, and harvesting but had limited control over the adoption of new technologies and practices (Halbrendt et al. 2014). However, the situation is changing, due especially to male labor out-migration, and women's role in agricultural decision-making is also increasing. It is evident from the study by Farnworth et al. (2018) that Nepali women have gradually increased their participation in farm management and their role in agricultural decision making.

The lack of access to and control over productive resources (land, capital, credit, water, etc.) and access to finances limit women's capacities to invest in new technologies and practices. Accessing loans and credit from financial institutions, in most instances, requires land as collateral — another set of challenges created by the social and cultural norms. Women continue to be constrained and marginalized by traditional gender roles that make them responsible for family care, restrict their mobility, and cause bias against female entrepreneurship.

Finally, barriers related to agricultural education and rural advisory and extension services are the result of low levels of education, low literacy rates, and less technical capacity amongst women and disadvantaged groups. In this context, greater participation by women and marginalized communities in ISFM practices would help overcome the gender and social inclusion (GESI) challenges that men and women farmers face and ensure equitable progress towards sustainable agricultural development.

3. ISFM best practices: NSAF's experiences

The NSAF project builds on the strong linkages among the various components of the agricultural value chain, including actors (farmers, agro-dealers, extension agencies, and research centers) and processes (research and development, extension system, and policies). The actors are interconnected through process-oriented linkages, and if a link malfunctions, the entire value chain is impacted and challenges the smooth functioning of the agri-food system. NSAF considers the differences in the capacities and opportunities to participate among this range of actors.

3.1. NSAF's approach to integrating GESI in ISFM

NSAF promotes the adoption of ISFM best management practices using an approach covering research, extension, and practice (Figure 1). The research entails reviewing past work and analyzing trial data to determine gaps in research, develop protocols for field trials and demonstrations, conduct field trials, and analyze data. The main focus of this activity is on on-farm validation trials and the creation of locally optimized agronomic packages. On-farm validation trials are carried out and managed in collaboration with local farmers and farmer groups such as cooperatives. The validation trials are a critical activity where domain-specific packages are developed and tested on farmers' fields. These trials determine appropriate soil fertility management interventions and identify farm-level production constraints and the benefits of agronomic interventions, including new fertilizer management techniques and hands-on experience in testing and observing change with science-led innovations. Farmer feedback is documented and integrated into follow-up trials for better accordance between NSAF activities and farmers' needs. The end-product is the creation of agronomic packages (seed, fertilizer, and agronomic practices) that are adapted to both the agroecology and farmer socioeconomic typologies.

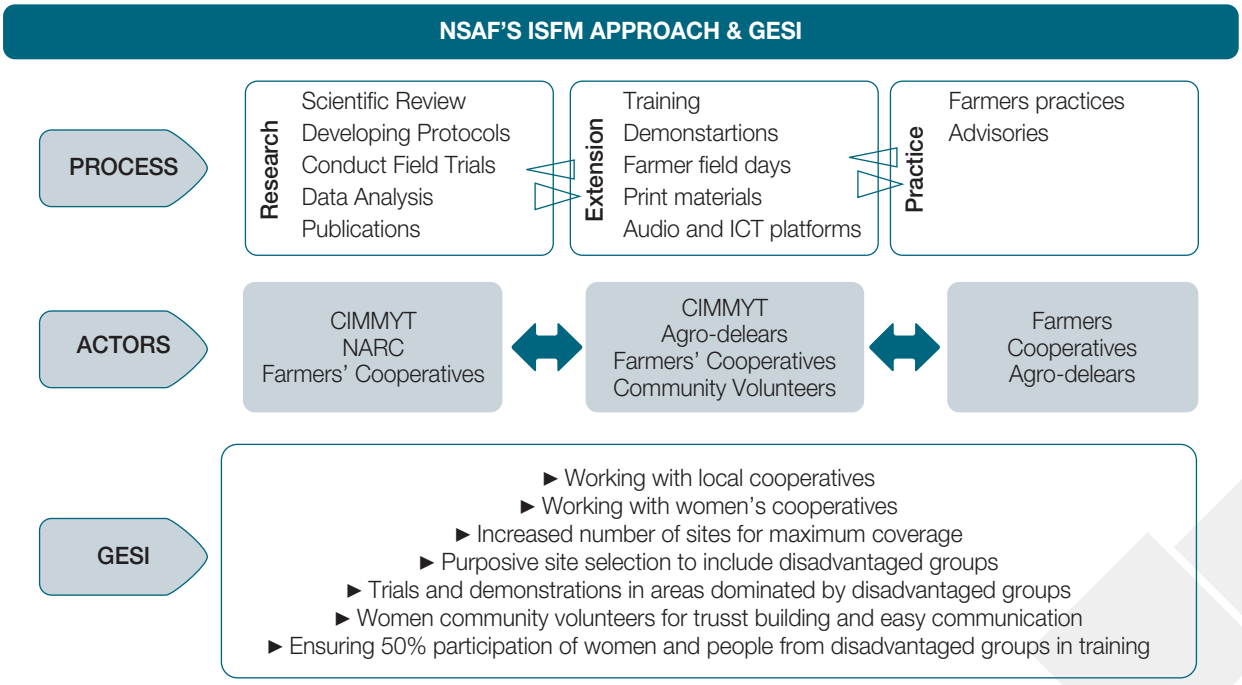

Figure 1. NSAF's conceptual framework for GESI in ISFM.

Extension includes demonstrations, training events, farmer field days, and sharing evidence, i.e., locally adapted and optimized agronomic practices from trials, through print and audio media and digital means. All these practices are combined as best management practices and are endorsed by MoALD and NARC. Outputs from local validation trials are translated into locally appropriate extension materials, including print materials (e.g., pamphlets, fact sheets, and instructional guides), multi-media support (video), and digital-based extension delivery including the use of smartphone apps (e.g., Geo Krishi) and SMS and radio-based systems to deliver customized extension messages, based on location and crop. These platforms serve both to amplify research impacts and create feedback loops between farmers and the agro-input supply chain. Finally, the practice and use of these available services and applications need to be applied by the diverse groups of farmers, including women, poor, and marginalized, for a sustainable and equitable impact. Through combined government efforts (e.g., by the former district agriculture offices and local governments), farmer institutions (cooperatives), and agro-dealers, farmers have access to inputs such as fertilizer and agri-extension services. This creates a greater demand for extension goods and services.

NSAF has introduced innovative ways to conduct ISFM research-for-development and to make the ISFM approach inclusive. The basic premise of the inclusive ISFM is, in fact, adopted from the conventional system of fertilizer management, but NSAF has built into that system by incorporating elements of gender and social inclusion in selecting participants for training, trials, demonstrations, and group operations, etc. The project has brought gender and other intersectional factors into consideration for implementing ISFM, considering the research, extension, and practice dimensions in the NSAF project areas. Table 1 highlights differences between the conventional approach and the NSAF's approach to ISFM.

3.2. Gender considerations for selecting local stakeholders

NSAF research participants are selected through farmers' cooperatives that have members from diverse communities and social groups. Research sites are selected in areas that have a significant number of disadvantaged communities. The project identifies and selects women, youth, and farmers from disadvantaged groups during plot selection for field trials, demonstrations, and farmer field days, so that they get the opportunity and knowledge to

Table 1. Comparison between conventional and NSAF approaches to ISFM

Theme	Conventional Approach	NSAF Approach
Research	Carried out on government research stations and farms. Farmers visit the stations to learn about research, which is not easy for most farmers, especially women and disadvantaged households and HHs further away from research stations.	Implemented in farmers' fields; overseen by trained community volunteers, including women. Scientists visit farm households, and research is participatory, farmers get to see and compare the benefits of ISFM over conventional practices.
Extension		
Topics covered	General; without site-specificity; follow the Department of Agriculture (DOA) Krishi Diary, and ISFM is often not the core focus but one of the topics; local research findings mostly lacking.	Tested practices from trials and demonstrations that are site- and crop-specific; cover improved application methods, the 4Rs (right source, right rate, right time, and right placement) of nutrient management.
Trainees	Mostly include people who are close to the local municipalities and research stations, who can travel outside of villages — mostly progressive farmers; often difficult for women and disadvantaged communities limited by resources.	Cooperative members, inclusive of caste, class, and ethnicity. Agro-dealers, civil society, and local government officials.
Training Sites and Providers	Mostly in research stations and agricultural service centers; conducted by experts from these centers and municipalities.	Organized by cooperatives, mostly in villages, and conducted by experts from the governments, NSAF technical staff, community volunteers, and lead farmers.
Dissemination	In-person training on research stations and farms; and conventional lecture-type training.	Uses a variety of measures such as demonstrations, farmer field days, digital tools, and radio to disseminate information; participatory training using interactive tools and games.
Practice/ Adoption	No follow-up on the use of the knowledge gained.	A regular follow-up by cooperative members and community volunteers on the use of new approaches, based on their participation in trials, demos, and farmer field days.

make technology adoption decisions on improved new varieties and ISFM practices. The project adopts a proactive approach to selecting cooperatives that are managed by women or have a significant number of indigenous people. The cooperatives identify farmers and sites for trials and demonstrations to have adequate representation of disadvantaged groups conducting these trials. The project also conducts trials and demonstrations in adequate numbers to ensure the representation of all ethnic communities that are members of the cooperative.

The selected cooperatives are oriented by the project's field staff to identify and prioritize farmers who are women or from disadvantaged groups. Meetings are conducted with the cooperative leadership to jointly assess the profile of the members and the proportion of women farmers or those from disadvantaged groups. The project engages volunteers (who are mainly women) from local communities to help bridge any prevalent gaps in the understanding of the issues between scientists and the local men and women farmers. These volunteers are trained, coached, and involved in trial and demonstration design and management. Being from the farmers' community, volunteers can better communicate with farmers, gather issues and challenges, and pass these on to the technical team, facilitating efficient two-way communication. The cooperatives make compulsory at least a 50% participation by women and disadvantaged groups in conducting field trials, demonstrations, training, and farmer field days.

Discussions are held on the status of disadvantaged farmers regarding access to land, soil heterogeneity, access to services, training, and information, and the need for further support. The cooperatives are then oriented on the need for inclusive ISFM research. Figure 2 shows the steps followed and the considerations in engaging with local cooperatives for research.

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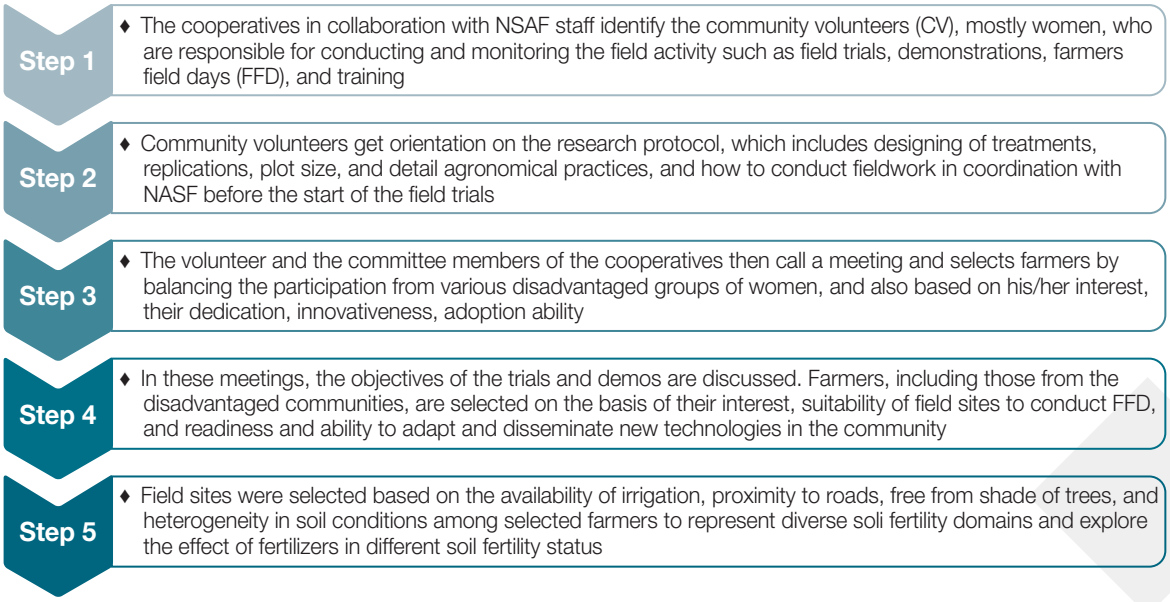

Figure 2: Steps for an inclusive engagement of local stakeholders.

3.3. Lessons learned

The cooperatives encouraged and invited women farmers and farmers from disadvantaged groups (DAGs) to participate in the ISFM field trials and demonstrations. Similarly, the cooperatives made it mandatory for at least 50% of the participants in farmer field days and training events to be women and farmers from DAGs, to scale out the ISFM best management practices in the community. Moreover, the community volunteers and cooperatives encouraged women farmers and DAGs to adopt best management practices and market their harvested products for economic development and sustainable livelihoods.

More than 40% of women and over 60% of DAG farmers conducted ISFM field trials and demonstrations for vegetable (tomato, cauliflower, onion) and cereal crops (rice, wheat, maize). Similarly, more than 50% of women and over 70% of DAG farmers participated in the ISFM best management practices training and farmer field days. These women farmers and DAGs were aware of the use of balanced fertilization (proper N, P, K ratios and levels of the micronutrients Zn, B, Mo) to improve nutrient-use efficiency and crop productivity. Before NSAF, farmers were not aware of the importance of balanced fertilizer use and used to apply only urea and Di-ammonium Phosphate (DAP). Now, the demand for other fertilizers, including muriate of potash, and B, Zn, and Mo, is increasing at project sites, as farmers see their crop yields increase.

Based on anecdotal evidence from the project field staff, women and DAG farmers have adopted ISFM best management practices and increased their vegetable productivity from 25% to 64%, fetching higher incomes (ranging from 25% to 50%) compared with their previous agronomic practices. This has helped farmers, mainly from DAGs, to raise their socioeconomic status through education (they are able to pay children's school fees) and household expenditure such as food and clothing. Moreover, their knowledge and use of ISFM technologies have helped boost their confidence in making farm-level decisions with the support of spouses and family members. A systematic survey or a randomized control trial is needed to assess the actual impact and develop evidence for broader scaling of the gender-responsive ISFM approach.

4. Suggested Framework for Gender-Responsive ISFM

NSAF worked on ISFM using the framework presented above, which outlines the context-specific local stakeholders and examples from Nepal. For its broader applicability and based on what we learned from NSAF, we suggest an inclusive ISFM framework (Table 2). The framework focuses on the three action areas relevant for soil fertility management: research (fertilizer trials), extension (training, service provision, on-farm demonstrations, farmers' field days), and practices (adoption of appropriate fertilizer management practices). To achieve gender-responsive results and advances in other GESI outcomes, we consider five decision points and the corresponding information required for GESI-responsiveness.

We suggest checklists for each key decision point. Each decision point under each action area is directed towards having a positive impact on gender equality, and requires agronomists, soil scientists, gender experts, and other key stakeholders to make decisions using reliable evidence on the gender-associated differences to which the work and participants are subject. Under each decision point, there is key information suggested that should be collected, a reminder checklist for each decision point, and the desired GESI-responsive results.

Table 2. Framework for gender-responsive integrated soil fertility management

Action areas*	Decision points	Information required for GESI-responsiveness	Decision checklist	GESI-responsive results
Research, Extension, Practices	1. What are the GESI-specific needs of users for practicing ISFM? What are the GESI gaps that limit benefit sharing and the opportunity to participate (action areas)?	• Farming systems, labor organizations, and gender roles. • Typology of users with gender-disaggregated data.	• Does the user profile include GESI considerations?	• User profiles with GESI dimensions.
	2. Who are the users we should target and what are their priorities?	• Intersectional information on male and female users/farmers. • GESI-gap profiles with priority agendas.	• Do sampling and targeting include GESI considerations?	• Equitable sharing of benefits of planned interventions (action areas).
	3. What are the selection criteria to reach target users/farmers?	• Methodologies for field research and extension activities.	• Do selection criteria address local diversity context? • Do alternative outcomes consider gender equity?	• Better adoption of planned interventions (action areas).
	4. What are the GESI constraints for effective implementation?	• Constraints faced by men and women to access goods and services. • Information about gender inequalities that are potential or actual bottlenecks to adoption. • Information on the institutional (or policy) barriers for men and women to participation.	• Are GESI-responsive strategies for integrated soil fertility management in use?	• GESI-responsive delivery pathways for goods and services.
	5. What to monitor and document?	• Gender-disaggregated data on perceptions of technologies and fertilizers in trials, and adoption by men and women before and after interventions. • Gender roles and decision-making in ISFM, drivers of uptake and use of ISFM technology and benefit-sharing.	• Is there an information system in place to track progress?	• Learning, feedback, and refinement of the framework.

* The action areas are Research (fertilizer trials), Extension (training, service provision, on-farm demonstrations, field trials), and Practices (adoption of appropriate fertilizer management).

5. Conclusion

In Nepal farming systems, men and women farmers have different levels of engagement and opportunity to influence the adoption and application of ISFM, resulting in different consequences and outcomes. Implementing ISFM requires access to and control over resources, along with technical understanding. There is no single measure for equitable benefits for women, men, and marginal farmers from ISFM. As with nearly all agronomic practices, soil fertility management is site- and context-specific, making it complex to develop a uniform approach. This paper demonstrates that even if fertilizer management does not seem to be gendered at first glance, smallholder farming is different, and ISFM needs to follow more gender-responsive approaches to derive maximum benefit from it. In this paper we have recommended aiming for tailored solutions so that diverse end-users can benefit equitably. Using the Nepal Seed and Fertilizer (NSAF) Project as an example, we have illustrated how inclusive ISFM could benefit women and socially marginalized populations, presented anecdotal evidence regarding potential positive impacts, and discussed project innovations to overcome socioeconomic and cultural barriers for inclusive ISFM research, extension, and practices in the project area.

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