Sustainable Intensification of Mixed Farming Systems

Sustainable Intensification of Mixed Farming Systems (SI-MFS) Initiative

Exploring Pathways for Addressing Systemic Problems in the Agricultural Sector: The Case of Abamote village, Bosana Worena woreda, Northern Amhara Region, Ethiopia

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The Sustainable Intensification of Mixed Farming Systems Initiative aims to provide equitable, transformative pathways for improved livelihoods of actors in mixed farming systems through sustainable intensification within target agroecologies and socio-economic settings.

Through action research and development partnerships, the Initiative will improve smallholder farmers' resilience to weather-induced shocks, provide a more stable income and significant benefits in welfare, and enhance social justice and inclusion for 13 million people by 2030.

Activities will be implemented in six focus countries globally representing diverse mixed farming systems as follows: Ghana (cereal–root crop mixed), Ethiopia (highland mixed), Malawi: (maize mixed), Bangladesh (rice mixed), Nepal (highland mixed), and Lao People's Democratic Republic (upland intensive mixed/ highland extensive mixed).

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Exploring Pathways for Addressing Systemic Problems in the Agricultural Sector: *The Case of Abamote village, Bosana Worena woreda, Northern Amhara Region, Ethiopia*

1. Background and rationale

Ethiopia's agriculture sector contributes to over 30 per cent of the country's GDP and supports an estimated 75 percent of the country's workforce. The sector is, however, facing growing challenges that threaten its continued contribution to food security and the national economy (Wondimu and Moral 2021). Among the prevalent challenges are increasing population growth which has in turn resulted in growing demand for arable land and its extensive use, further leading to land fragmentation and degradation (Wondimu 2021). The sector has also been affected by climate change and variability including drought, the outbreak of pests (e.g., locusts) and diseases, and invasive alien plant species (Demem 2023). These, combined with limited access and use of improved technologies and innovations have compromised the profitability and sustainability of the sector, and its ensuing implications on national food and nutritional security, and employment.

The Amhara Region is characterized as a highland with low rainfall distribution, and where a mixed crop-livestock farming system (FS) is predominantly practiced by smallholder farmers who use traditional or less efficient agricultural technologies and practices. The crop-livestock mix offers farmers diverse sources of food and income. However, the interdependence of crop production and livestock husbandry requires systemic management to ensure that resources are used efficiently, and that trade-offs and risks are managed effectively. A FS in this context represents prevalent farm systems that rely on similar resources bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate (Dillon et al 1978 and Shaner et al 1982).

Bosana Worena is one of the woredas in the Amhara region where many of the CG centers partnering under this Initiative previously worked in. The FS of the woreda was characterized through successive consultation meetings held with relevant stakeholders including representatives from the Ministry of Agriculture at regional, zonal and woreda levels; national agricultural research systems, experts from regional universities, researchers from participating CGIAR centers, as well as farmers on the ground (Siefu et. al. 2022); and a biophysical site characterization report generated by Alliance Biodiversity & CIAT (Biophysical characterization Sustainable Intensification Sites.pdf). In addition to characterizing the system, the consultation processes also helped in identifying and prioritizing the key components and challenges in the system. The characterization was further corroborated through farm typologies that were developed using data collected through the Africa RISING project (*Mark Caulfield & Jim Hammond*, 2022 – unpublished work). The typologies provide a more comprehensive understanding of the variations within the FS (Table 1).

What is critically needed are **rapid and efficient systematic tools and approaches** that can be used to identify appropriate *entry points for sustainable intensification of the agricultural system* and guide the integrated packaging of technologies and practices into sets of innovation bundles that can be piloted.

Our objective is thus to provide and apply a descriptive system analysis of production systems, which can help identify possible entry points towards sustainable intensification, as well as guidance towards efficient packaging of transformative innovations.

The methodology is based on descriptive participatory analysis and focus groups discussions. More methodological insights can be found in Frija et al. 2023[1].

Table 1: Farm Typology

Farming HH type	Number of HHs (% of sample)	Description of farming HH type
Diversified commercial oriented farms("Diversified")	40 (16%)	These farming households generate significantly higher levels of off-farm income compared to other farming households (although generally off-farm income remains relatively low – 494 Ksh year^{-1}). Diversified farming households also generate the most livestock and crop production income (21,204 Ksh year^{-1} and 36406 Ksh year^{-1} respectively) and are the most market oriented, selling more than half of their production to market. Farming household size is smaller than the Moderate-income farming households comprising around 3.3 members per household.
Moderate-income farms ("Moderate-income")	60 (24%)	These farming households generate significantly more income from crop and livestock farm production than the subsistence farms (around 3000 Ksh year^{-1} per production stream). While this income is less than Diversified farming households, the difference is not significant at the 5% level of probability. On the other hand, Moderate-income farms own more livestock (5.94 TLUs) and cultivate more land (than any other farming household type (2.23 ha) (although these differences are not significant at the 5% level of probability compared to the Diversified farming households. Moderate households are also large, comprising on average more than 4.5 members per household, which is significantly different to all other farming household types. One of the main differences to Diversified farming households is that Moderate-income farms generate virtually no income from off-farm income sources.
Large subsistence farms ("Large subsistence")	60 (24%)	These households are characterized as generating little on- or off-farm income and selling very few farm products to market (13%). These farming household types differ from the "small household subsistence farms" in terms of household size, generally comprising of more than one household member more than these farming households (an

[1] Frija, A., Alary, V. and Idoudi, Z. 2023. Tool for Descriptive Design of Farming Systems: Components, Priorities, and Sociotechnical Packages towards Sustainable Intensification of Mixed Crop Livestock Systems. Ibadan, Nigeria: IITA. https://hdl.handle.net/10568/135982

Farming HH type	Number of HHs (% of sample)	Description of farming HH type
		average of 3.82 household members compared to 2.37). Large household subsistence farm households also own more farm assets (3.79 livestock TLUs and 1.32 ha of land cultivated) compared to their smaller counterparts (1.16 livestock TLUs and 0.99 ha of land cultivated).
Small subsistence farms ("Small subsistence")	90 (36%)	These farming households are similar to "large household subsistence farms", in that they sell little farm produce to market and generate little income however, their household is smaller (on average just over 2 household members – 2.37) and they have fewer farm assets (1.16 livestock TLUs and 0.99 ha of land cultivated).

2. Which systemic approach to identify entry points towards sustainable intensification of farming systems in Woreda

A CGIAR joint assessment of the woreda was conducted and resulted in the identification of Abamote in Bosena Worena as the common village where all Centers could implement relevant socio-technical innovations that were identified through an internal CG workshop. The FS in *Abamote* is best characterized by a mixed crop-livestock system that primarily relies on rainfed agriculture which is complemented with small-scale irrigation schemes. A total of 15 farmers who reside in Abamote were further identified as "demonstration sites" to pilot the bundles of technologies proposed by the different CG centers and collectively explore pathways for enhanced system integration and analysis.

However, when asking the question of what to pilot towards SI, we were confronted with the challenge in finding a "rapid" systemic approach that can be used to better understand the entry points for systems transformation, and innovation bundling. We find that is a critical gap in the pursuit of sustainable mixed farming systems. Efforts were made by Frija et al. (2023) to develop a Tool for Descriptive Design of Farming Systems (TDDFS) components, priorities, and sociotechnical packages towards SI. The tool was tested in three countries including Bangladesh, Nepal (Neupane et al., 2023)[2] and Ethiopia. In this report, results from the application of the tool in Ethiopia will be presented.

This instrument was designed to serve as a facilitation questionnaire for national multidisciplinary teams operating within the framework of Work Package 3 on Sustainable Intensification of Mixed Farming Systems (SI-MFS) initiative. It includes a series of questions aimed at delineating local mixed farming systems and highlighting the entry points and trajectories (including socio-technical innovations) that will enable sustainable intensification to be achieved. Its implementation requires a one-and-a-half-day collaborative session with multistakeholder partners who are well knowledgeable and aware of local conditions and specificities of the production systems' object of study.

Accordingly, a workshop was conducted in Addis Ababa to establish a general description of the FS components, the immediate priorities, and the socio-technical packages that are readily available for the sustainable intensification of the system in the Woreda. The workshop was held on the 7th of July 2023, and was attended by representatives from partnering regional agricultural research institutes, universities, private investors, as well as relevant zonal and woreda level departments. The output of the workshop was used as a framework to organize information that was previously gathered through consultative meetings and site characterization reports. The framework was used to establish the basic enterprises of the FS, the main technologies used within the FS, as well as the institutional arrangements that support it. Key components under each basic endowment were analyzed to identify the core challenges and the interlinkages within and across the different components (Table 2).

The analysis was used to explore pathways for systemic integration across the different components and CG Center-led activities that can lead towards better integration, intensification, and diversification within

[2] Neupane, N., Koirala, S., Karki, D., Khadka, M., Shrestha, N., Jibesh, K.C., Pandit, A., Cheesman, S. and Frija, A. 2023. Harmonization of Work Packages in Mixed Farming: A descriptive design of farming systems components, priorities, and sociotechnical packages towards sustainable intensification. Ibadan, Nigeria: IITA. https://hdl.handle.net/10568/135864

the system, and in line with the Initiative's conceptualization of *sustainable intensification*, i.e. *the production of more food on the same piece of land while reducing the negative environmental impact, by:*

(i) *ensuring efficient co-development, coordination, integration and transfer of innovations, information, tools, and standardized methodologies, and*

(ii) *integrating multiple biophysical and socio-economic thematic-level outputs and identifying strategies that minimize trade-offs and maximize synergies, resulting in multiple impacts at scale.*

The analytical process was conducted by following the steps outlined below (see also Frija et al., 2023).

1. **Prioritization of the core challenges** of the system based on their level of linkages with the other components and hence their effect on the greater FS,
2. Identification and promotion of systemic solutions:
    a. that have greater potential for **integration within and across** existing and newly introduced innovations for greater systemic impact, including integration across solutions promoted by the different CG centers,
    b. that create evidence-based pathways for sustainable **intensification and diversification** of farming practices and livelihood strategies for a more resilient and sustained systemic impact,
3. Exploring and exploiting opportunities that **enhance community engagement** for co-creation of knowledge, adaptation to local conditions, and sustainable adoption of promoted systemic solutions, and
4. **Inclusive awareness raising and capacity development** of individual farmers, communities, and relevant institutions to ensure the sustained adoption of the

Table 2: Basic components of the FS, challenges faced, and interlinkages with other components of the FS

ID of system component	Basic endowment of the FS	Description of the component	Challenges with the component	Linkage with the other components
1.1.	Soil	Clay soil, stone bunds are commonly constructed at farm level to reduce erosion,	Depletion of soil fertility - farmers' have limited access to fertilizers (quantity and quality), often apply manure to enhance fertility, waterlogging and acidity are a problem	2.1 – 2.3, 3.1, 4.1 – 4.3
1.2	Farmland (size, tenure, etc.)	Increasing population pressure and urbanization	Land fragmentation, competition between different land-use options including competing interest between growing forage, crops for human consumption, and wood lots	2.1 – 2.3, 2.5, 3.3. 4.2
1.3	Grazing area	Free grazing is allowed but such communal spaces are very limited and degraded	Growing population and increasing demand for farmland – reclining access to communal grazing land	1.6, 1.9, 2.3, 4.3
1.4	Forest	State owned and managed forest part of NR conservation, deforestation due to increasing demand for fuel wood and different land-use options	Deforestation to meet growing demand for fuel wood and land	1.1, 1.5
1.5	Water	Rainfed agriculture, some small streams are available that can be tapped for some small-scale irrigation to supplement fodder and vegetable production	Rainfall variability (timing, duration, and intensity) constrain production and productivity of crops, not much investment in rainwater harvesting, unexploited potential to develop small-scale irrigation systems that could increase diversification and intensification of the production system (cereal, forage, and food legume crops with high harvest index)	1.6, 1.9, 2.1-2.3, 2.5, 2.7, 3.1, 4
1.6	Landscape	Has several sub-watersheds with established terraces, soil and stone bunds, cut-off drain physical and biophysical structures like Lucerne	The area is prone to soil erosion due to the natural terrain of the land, intensity of the rainfall, and lack of integration of biological coverage of the landscape	1.1, 1.5

		tree and Phalaris grass are implemented		
1.7	Labor	Community mobilization for soil conservation activities is common (Jan-March), family labor used in farming with occasional use of hired labor or community support during busy seasons	Unprofitability of the FS often pushes the youth to seek off-farm employment elsewhere	2, 3, 4.1
1.8	Markets		Weak input-output markets, availability and accessibility of essential agricultural inputs, lack of services for quality control and certification, farmers' profit margin compromised by middlemen, poor market linkage for milk producers,	2, 3 and 4
1.9	Climate/weather	Subtropical highland climate, annual average rainfall of >1300>rainy season falls during the months of June-September; mainly falls within the *degu* (2300-300 mt a.s.l.) and weynadega (between 1500-2300 mt a.s.l.) agroecology	Rainfall variability (timing, duration, and intensity), frost occurrence/desiccating wind hazards, recurrent drought	1.1. 1.3, 1.5, 2.1-2.3, 2.5,
2	**Basic enterprises of the FS**	**Description**	**Challenges**	**Connection with key components of the FS**
2.1	Major field and forage crops	Wheat, barley, faba bean, lentil, field pea and linseed Forage - hay, crop residues (straw, stovers and haulms from cereals and pulses), grazing land, concentrates (cakes, molasses, wheat bran), and cultivated feeds (oat, vetch, tree lucerne, desho grass and phalaris) tree	Biotic (pests and diseases) and abiotic (waterlogging, acid soils and drought) that affect crops, timely and adequate access to seeds of improved crop and forage varieties, poor access to chemical inputs (fertilizers and pesticides), seed system is not linked with crop seed growers in north Shoa, only few varieties are available and greater varietal	1.1, 1.2, 1.5, 1.6 - 1.9, 2.3, 2.6, 2.7, 3.1, 3.3, 4.1 - 4.3

		lucerne, forage oat, alfalfa and fodder beets	portfolio of wheat, barley and faba bean as well as other fodder crops is needed.	
2.2	Horticulture	Beetroot, onion, garlic, carrot, potato, tomato, lettuce, cabbage, and spinach		1.1, 1.2, 1.5, 1.7 - 1.9, 2.7, 3.3, 4
2.3	Livestock (Cattle, sheep and goat)	Cattle, sheep, and goat are the main animals produced and contribute to the economy. Dairy farming and fattening of both small and large ruminants are the main contributor to the economy and becoming the major job opportunity for youths and women.	Feed shortage, poor feed resource utilization, low feed production, limited forage species diversification, poor knowledge of and access to balanced feed – farmers mainly rely on crop residues and to a lesser extent on forage production, soaring of industrial and commercial feed resources, poor market orientation of feed production, inadequate veterinary infrastructure and services, limited access/knowledge of AI, poor performance of local and non-improved sheep and diary breed performance, traditional livestock and fattening system	1.1, 1.2, 1.3, 1.5, 1.7 -1.9, 2.1, 2.2, 2.5, 2.7, 3 and 4
2.4	Poultry	Semi-intensive and used both for household consumption and income generation (chicken and eggs)	Low level awareness on feeding and housing of egg laying improved chickens, the chicken flock is too small to appreciate their potential contribution to household income and nutrition	1.1, 1.7, 1.8, 2.2, 2.7, 3.3, and 4.
2.5	Agroforestry	Some fruit trees	Not integrated into the system – its potential to provide shade for other crops, or its use to enhance animal feed, and support apiculture are not fully exploited	1.1, 1.2, 1.4, 1.6, 1.8, 1.9, 2.6, 2.7, 3.2, 3.3, and 4.
2.6	Apiculture	Mainly use traditional hives to produce honey for home consumption and to generate income	Very limited use of modern production methods, no quality control or certification to warrant premium selling price, opportunities for expansion not fully exploited	1.4, 1.7 -1.9, 2.1, 2.2, 2.7, 3 and 4

2.7	Value addition and Off-farm employment	Women are actively engaged in the processing and marketing of local drinks and dairy products (semi-intensive), while the youth are commonly engaged in marketing their labor (seasonal) and animal fattening (small and large ruminants)	Lack of mechanization limits opportunities for expansion and improvements in product quality, lack of quality control and certification of quality for premium marketing	1.7, 1.8, 2.1 – 2.6, 3 and 4
3	**Main technologies used within the FS**	**Description**	**Challenges**	**Connection with the other components**
3.1	Farming implements	Draught animals used for land preparation, manual and labor-intensive traditional methods of harvesting	Lack of sufficient technology demonstrations, poor mechanization, low adoption of improved technologies	1.7, 1.8, 2.1 -2.3, 2.7, 4.1, 4.2
3.2	Beehives	Traditional hives	Very limited use of modern beehives that could enhance the productivity of the bees and the quality of the honey, lack of integration of bees into the production system as pollinators of crops that produce fruits and seeds	1.7, 1.8, 4.1 and 4.2
3.3	Processing innovations – for value addition	Manual, labor intensive, traditional methods to process atelia (by-product of barley), animal feed, honey, dairy processing, etc.	The lack of mechanization in land preparation, harvesting, and processing limits the intensity of the production system and curtails potential opportunities for integration of the different enterprises	1.7, 1.8, 2 and 4
4	**Institutional frameworks**	**Description**	**Challenges**	**Connection with the other components**
4.1	Financial Institutions	The Amhara Credit and Saving Institution (ACSI) offers credit for the purchase of fertilizers and other agricultural inputs	Interest rate is quite high, types of loans offered are limited, required loan guarantees are beyond the reach of many smallholder farmers,	
4.2	Service providers	Extension services under the MoA supports the transfer of information	Inefficient extension system – limited knowledge and specialization, lack of	

		and innovations to farmers; limited veterinary service, etc.	adequate and timely technical support, inadequate veterinary services	
4.3	Social/Community based organizations	Farmers' cooperatives that facilitate access to agricultural inputs, and marketing opportunities	seed system is not linked with crop seed growers in north Shoa	These more or less cut across the FS

3. Resulting socio-technical packages for SI-MFS in Woreda

By counting and assessing the number of system components which are the most central[3], we can then identify the related key innovations which can help upgrading their respective level of performance, and thus allow to leverage the overall system integration and performance. The resulting set of innovations for prioritizing central system components is thus considered as our transformative bundle towards sustainable intensification. The resulting innovation packages promoted by the different Centers aim to enhance the **integration, intensification, and diversification of the system** by focusing on the components that have greater linkages with other components – be it linkage with the natural endowments, the enterprises that depend on it, the technologies in use, and the institutional frameworks within which they exist. As such they focus on promoting:

(i) **Feed crops and varieties** (e.g. oat vetch, desho grass, fodder beet, and alfa alfa) that increase overall feed availability, offer better nutritional value, could be mixed with other outputs of the system and be formulated as an improved feed, contribute to improving soil nutrients, and are amenable to mechanization.

(ii) **Multi-purpose trees -** For example: the lucerne tree which is a fast-growing nutritious fodder tree/shrub can be used as feed for animals, fixes nitrogen into the soil thereby improving soil fertility, reduces erosion, enhances apiculture by offering bees nectar, and if managed well can be used as fuelwood by the household.

(iii) **Food and/or feed crops and varieties** that are adapted to local conditions and serve multiple purposes. For example, barley which can be used as food, for the preparation of drinks both for household consumption and income generation, and animal feed (the by-products of the local drink produced). Legumes are also promoted to improve household nutrition, offer protein rich feed alternative for animals, and improve soil fertility by fixing nitrogen in the soil.

(iv) **Feed formulation and mechanization** – to make efficient use of nutrient rich farm outputs including crops, vegetables, and fodder – for maximum benefit to farm animals. The formulation is mechanized to save labour and minimize wastage.

(v) **Integrated beekeeping and poultry** to diversify income and make use of available resources.

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[3] By central we mean those which were cited as the most linked to other system components in Table 2.

(vi) **Vegetable production** to improve household nutrition, enhance the nutritional content of feed mixes, income diversification, and make effective use of small land spaces.

(vii) **Seed multiplication** and crowd sourcing to ensure adequate and timely access to seeds of improved crop and fodder varieties.

(viii) **Intercropping** with trees such as avocado and apple trees that produce marketable fruits offering opportunities for income diversification, and more efficient utilization of the land.

(ix) **Sheep fattening** for income generation – especially for the young farmers.

Figure 1 below is the schematic for the systemic approach we developed which has been applied to Abamote village as a test case as described above to establish the linkages, identify constraints, and develop mitigation strategies.

Figure 1: Exploring pathways for systemic integration – a schematic presentation.

Exploring pathways for systemic integration- MFS-Eth

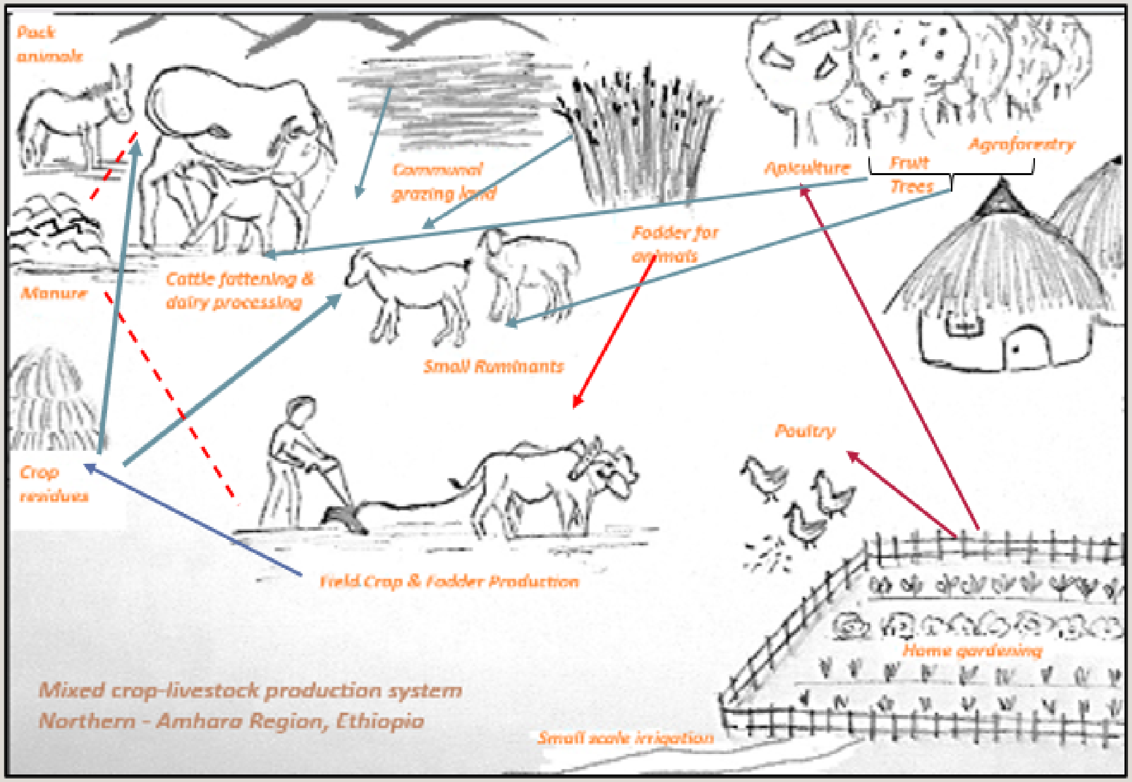
Core challenges

-Soil degradation
-Competing land use options
-Feed shortage
-Limited forage species
-Low crop productivity
-Low feed utilization
-Weak linkages to input-output markets
-Inadequate availability of crop and forage seeds
- Traditional production and processing (field crops, diary, feed, apiculture, etc.)
- Insufficient access to information & technologies
-Poor household nutrition
-Poor knowledge on housing and feeding egg laying chicken, and apiculture and flora management

Community engagement: Participatory varietal selection (barley, field pea and food oat), women business organization, crowd sourcing (faba bean and wheat bread) seed varieties

Prioritized challenges with greater effect on the system
Systemic Challenges_N Amhara MFS_2023.docx

Promoting solutions with greater potential for intensification, diversification, integration, community engagement, and capacity development to sustainably enhance the efficiency of the system



Integration: -Promotion of **multi-purpose feed options** – *Desho*, alfalfa, and *Lucerne* tree which enhance soil fertility, oat-vetch which crowd out weeds and produce lots of biomass

-**Feed formulation** – better utilization and balance (crop, vegetable, and fodder)
-**Intercropping** with fruit trees
-Promotion of **seeds of improved varieties** with greater biomass for animal feed (lablab, food-feed oat)
-**Integrating beekeeping** and **poultry** with home gardening, fruit and forage trees

Intensification and diversification: timely and adequate access to **seeds** of improved crop and fodder varieties (seed multiplication), **sheep fattening, feed processing and formulation, milk processing** (quality/quantity), mechanized feed processing, improved ***atela*** (used for animal feed and local drink) production, **increasing the flock of chicken** to enhance hh nutrition and income, **upgrade traditional** beekeeping practices

Inclusive awareness raising and capacity development on feed value chain, feed formulation (mix ratio), crowd sourcing, feed and forage, sheep fattening, financial literacy, radio broadcasts, and experience sharing.
-Enhancing institutional capacities of local partners (participatory process in problem identification and prioritization, innovation bundling, and implementation).

4. Capacity Development

As presented in the diagram above, the technologies are promoted within a broader framework of a holistic approach that also focuses on inclusive awareness raising on system thinking and technology adoption; and building institutional capacity to ensure sustainability of achieved outcomes. Awareness raising is done through multiple ways including radio broadcasting, effective community engagement, and other extension delivery mechanisms. Targeted training is also offered on feed value chain, feed formulation, crowd sourcing for seed selection and management, feed and forage choices, sheep fattening, and financial literacy.

Gender is mainstreamed throughout the process with special emphasis on identifying varieties that are preferred by women for better processing and marketing and exploring opportunities for income generation and diversification for women and youth.

5. The way forward

The process of exploring pathways for enhancing systemic integration across the different components of the system will continue into 2024. Through this process, we hope to identify plausible and dynamic methods/innovative pathways to enhance systemic integration throughout the process.

6. Acknowledgments

We would like to thank all Funders who support the Sustainable Intensification of Mixed Farming Systems (SI-MFS) Initiative in Ethiopia and partnering CGIAR centers without whose support and collaboration such systemic pathways cannot be explored.

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