RAISE-FS experience brief # 02

Using a food systems approach in practice: The case of lentil innovation in the Oromia Region of Ethiopia

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This brief presents the SWR Ethiopia RAISE-FS project and Ethiopian Agricultural Research Institute (EIAR), Bishoftu Agricultural Research Centre experience in translating food system theory into practice, to drive food system transformation. Using the lentil innovation case in Oromia Region, Ethiopia, it showcases effective strategies for improving the lentil sector and provides a best practice guide for similar transformative efforts.

1 Introduction

Lentil offers a multitude of benefits within the Ethiopian food systems. It is nutritionally rich so serves as a nutritious food source, provides essential feed for livestock, and generates cash income for farming households. Additionally, it contributes to job creation through off-farm value addition and processing activities, thereby supporting livelihoods and economic growth. Moreover, it plays a crucial role within different types of farming systems by improving soil fertility and promoting sustainable agricultural practices (Fikre, 2023; Tsega & Tesfaye, 2023; Damtew et al., 2023; Kore, 2023).

Historically, the cultivation of lentils has been prevalent across Ethiopia. Nevertheless, lentil production and productivity have experienced a declining trend since the late 2010s, leading to a situation where the country has turned from a net exporter to an importer of lentils (Damte & Tafes, 2023). Several factors have led to a decline in production, including the frequent occurrence of emerging viral and fungal diseases such as Fusarium wilt, root rot diseases, rust, Ascochyta blight, and stunting virus. Additionally, constraints such as the limited availability of improved seed varieties, waterlogging, insufficient management practices, and inadequacies in the extension system have further exacerbated the situation (Fikre, 2023).

To address the aforementioned challenges, the Bishoftu Agricultural Research Centre, in collaboration with the SWR Ethiopia RAISE-FS project, validated, demonstrated, and scaled lentil innovations. This brief describes how lentil production can be optimised using a food systems lens.

Objectives

- To compile the lentil food systems innovations derived from validation, demonstration and scaling activities.
- To document lessons learnt concerning technological and institutional innovations in lentils and facilitate further scaling and institutionalisation processes.

KEY messages

- Lentil production in Ethiopia is crucial for food security, nutrition, soil health, and livelihoods but faces challenges like diseases, poor seed systems, and environmental limitations.
- The Bishoftu Agricultural Research Centre and the SWR Ethiopia RAISE-FS project have introduced and scaled innovative solutions to address these challenges through Research for Food System Transformation.
- A food systems approach can optimise lentil production, focusing on crop management, inputs, crop protection, postharvest handling, market access, and food safety.
- Promoting gender equality and social inclusion improves the lentil value chain and socio-economic benefits by empowering women in decision-making related to lentil production, marketing, income management, and consumption through couple-based approaches and gender-focused training.
- Crop innovations contribute to food system transformation by improving health, nutrition, and environmental sustainability.

2. Approach

Effective revitalization of lentil production and utilization in Ethiopia requires adopting a systems approach. Following the food system framework (van Berkum et al., 2018; Figure 1) this brief addresses key challenges and opportunities to enhance lentil production and utilization. In doing so, it incorporates recommendations to optimize food system activities and to integrate considerations regarding socio-economic and environmental drivers into the design of innovation bundles specific to lentil.

This food system framework offers a systemic approach to explore the synergies and connections among various food systems components, aiming to enhance food and nutrition security, and socio-economic and environmental food system outcomes through lentil innovations (Borman et al., 2022).

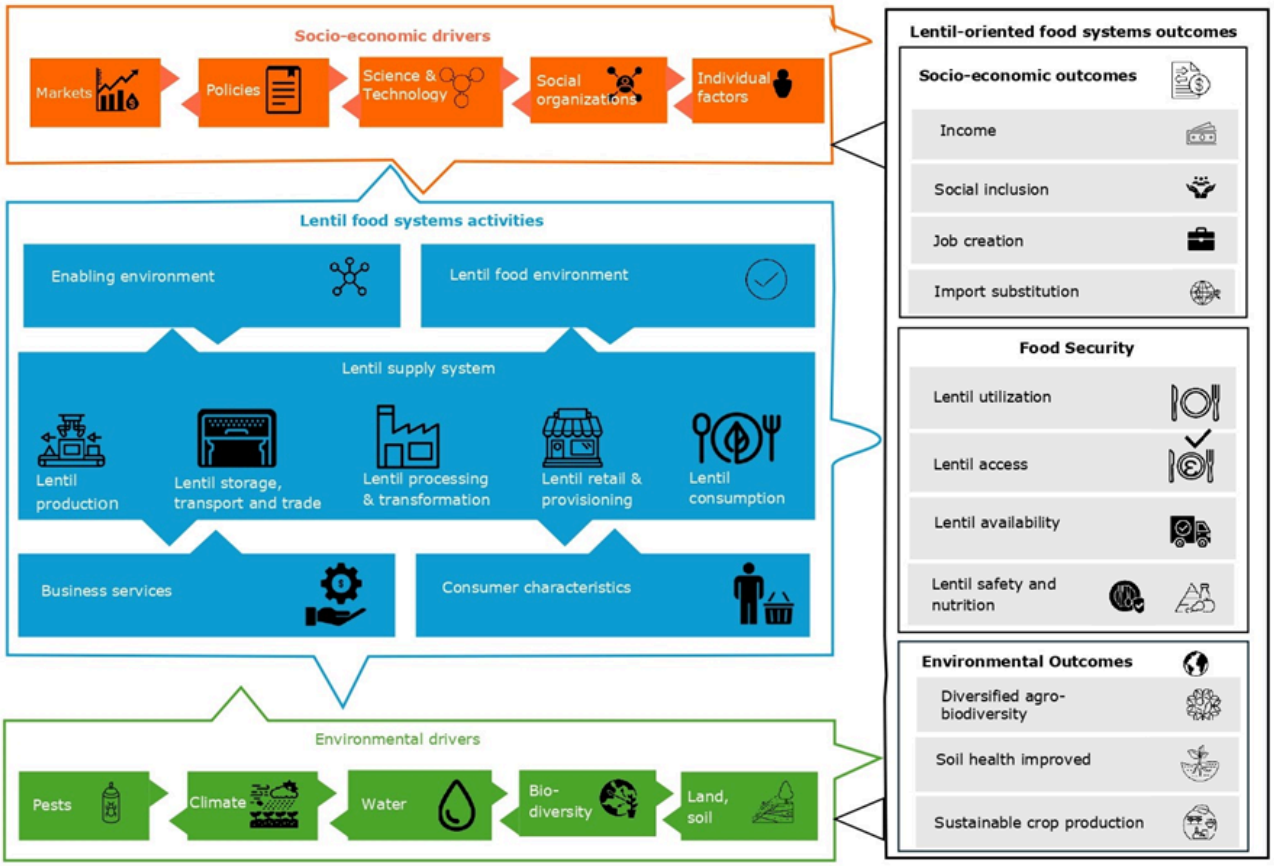


Figure 1. Food systems framework - Source: adapted from van Berkum et al. (2018)

The brief covers various aspects of the lentil food systems, including gender equality and social inclusion, agricultural inputs (seed, fertilizers, and pesticides), sustainable production practices, market linkages, nutrition, and food safety, as well as the enabling environment for the lentil value chain. The different innovations are bundled into so-called innovation bundles.

Ada'a woreda was the testing location for the lentil innovation bundles (Figure 1). Ada'a woreda has a long history of lentil production, and farmers are experienced. The woreda is among the most suitable lentil production areas because of its favorable agro-ecological conditions including soil, rainfall, and altitude.

The validation and demonstration of lentil innovation bundles included bottom-up planning (described in section 3.1), training, participatory variety evaluation, demonstration of production and cooking, and seed system activities aimed at revitalising production and enhancing lentil-orientated food systems. Consequently, these technological and institutional innovations (e.g., seed system, extension services, stakeholder linkages) for lentils have been recommended for scaling to promote sustainable lentil production and value chain development. Initial scaling efforts were made in 2024 based on the promising results obtained through validation and demonstration activities.

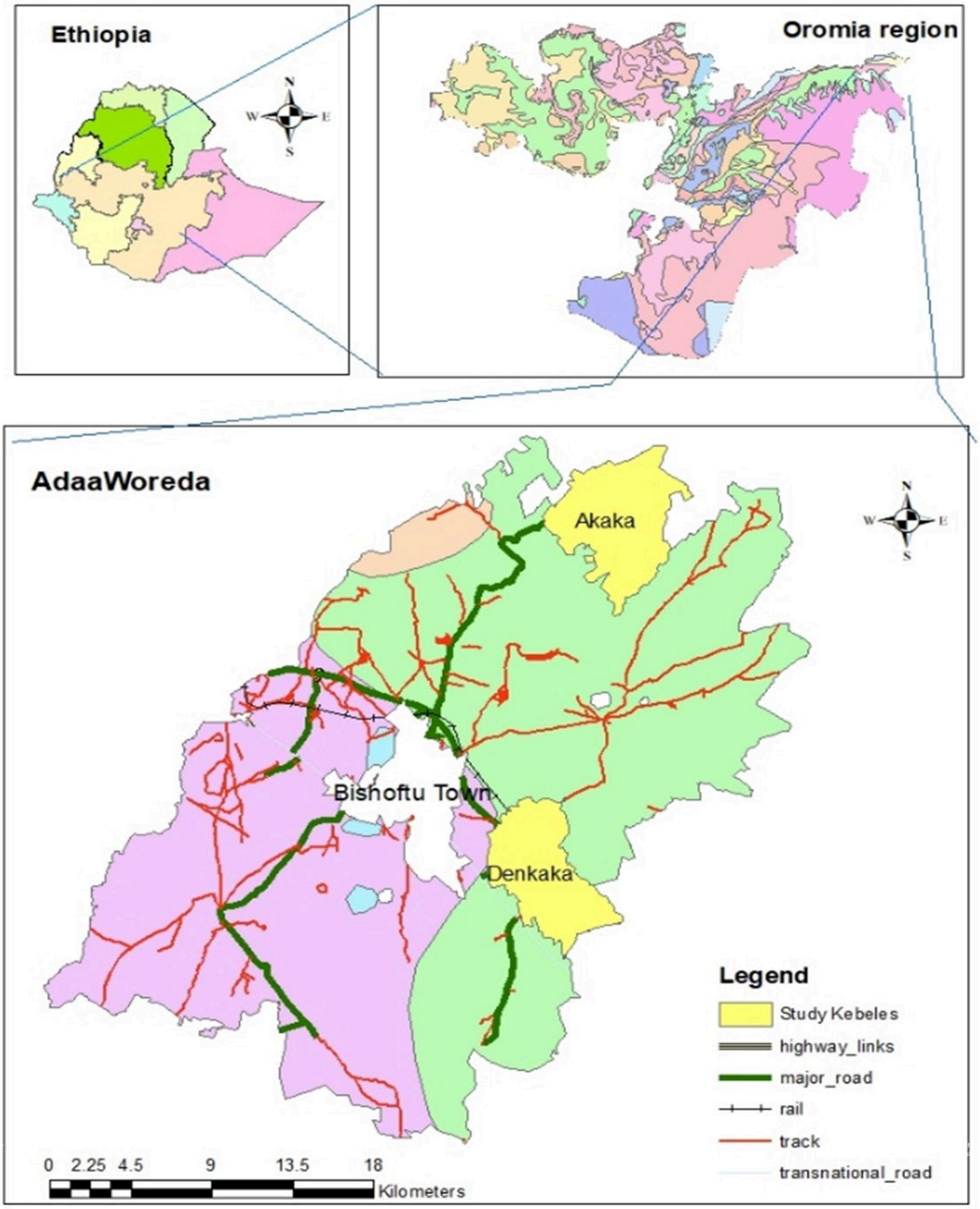


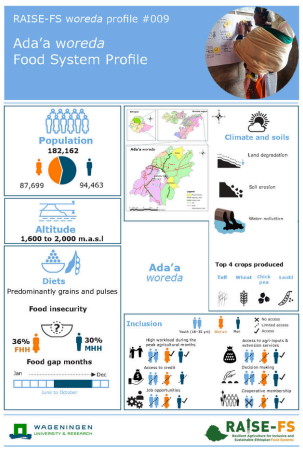
Figure 2. Map of Ada'a woreda

3 Lentil Innovation

3.1 Evidence-based integrated bottom-up planning

A Rapid Food System Appraisal (RFSA) was undertaken in Ada'a *woreda* as part of a bottom-up planning approach (Snel et al., 2022). The RFSA provided diverse and integrated perspectives from local actors on the current lentil food system, key challenges, opportunities, and potential leverage points; see the Ada'a *Woreda* Food System Profile. Based on the obtained stakeholder inputs, the main identified and prioritized leverage points for lentil production and utilisation included:

- improving production and productivity,
- enhancing sustainable production system,
- soil fertility management
- improving the input system,
- integrated pest management (IPM),
- post-harvest and value addition,
- customized and inclusive extension services,
- facilitating inclusive financial access to women and youth,
- promoting nutrition education,
- transforming negative social norms, and
- reducing gender inequality.

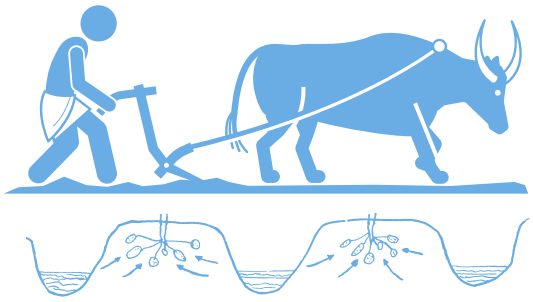


Based on the findings of the RFSA, the lentil interventions were designed and bundled to address the identified challenges within the lentil food system context. The following sections of this manual describe how the validation and demonstration activities took place; however, they need to be considered together as essential elements of the innovation bundle for optimisation of lentil production and utilisation.

3.2 Crop management practices

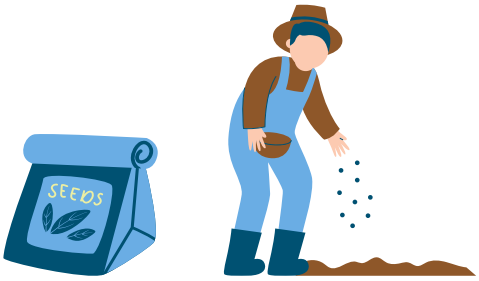
Cropping system: The predominant cropping system practiced in lentil production areas is crop rotation, which is one of the most important cultural practices for disease control. Lentil serves as a key crop in the cereal-legume rotation system, especially in areas with vertisols. It is typically grown in short-term rotations with cereals like wheat and teff. The recommended crop rotation sequence involving lentils is lentil-teff-wheat-lentil. Given lentils' susceptibility to soil-borne pathogens, it is essential to have a break period without lentil cultivation for 2-3 years. The strategic crop sequencing includes non-host plants in the rotation scheme to reduce pathogen inoculum levels for foliar diseases such as rust and Ascochyta blight, as these pathogens cannot infect non-host plants. Besides, having legumes in the rotation supplements the soil with nitrogen, which is beneficial for subsequent crops. As a result, lentils play a crucial role in managing soil fertility and soil health and reducing farming households' dependency of chemical fertilisers in the prevalent cereal-legume rotation system.

Drainage: Lentils are majorly cultivated on vertisols, which are characterised by waterlogging. Improved draining techniques recommended for surface drainage are broad bed and furrow (BBF) and ridge and furrow (RF). Excess water level in the soil not only affects the productivity of the crops but also promotes the development of soil-borne diseases such as Fusarium wilt. In the field trials, farmers were advised to implement recommended draining methods indicated above (BBF and RF) to remove excess water from their lentil field. Besides, farmers were advised to grow lentils on lands with gentle slopes and use ridge and furrow methods that enhance water drainage from their fields.



Recommended ploughing methods: *broad bed and furrow (BBF) and ridge and furrow (RF)*

Improved varieties: Participatory Variety Selection (PVS) was conducted on recently released varieties and compared with local varieties, resulting in the selection of Derash, Baredu, and Furi varieties as the most promising varieties. These varieties are recognised for their high yield, relative tolerance to diseases, early maturity, and preference by both male and female farmers based on their preference ranking. Subsequent validation, demonstration, and scaling of these varieties, along with recommended agronomic and crop protection practices, showed that Baredu and Furi performed best in three consecutive years, from 2022 to 2024.



Recommended lentil varieties: *Derash, Baredu, and Furi varieties*

In addition, training on producing quality lentil seeds at the farmer level was provided. These established seed producers are in the process of licensing their activities with the support of the Woreda Office of Agriculture and Cooperatives. Furthermore, market linkages are set up to support farmers in selling their seeds at a better price. The long-established informal seed exchange system, where farmers trade lentil seeds for other commodities in the area, also remains a mechanism for acquiring and accessing seeds. Support was also provided to farmers supplying lentil seeds to neighbouring farmers until the formal seed supply system in the area was fully strengthened. Highlights of the seed multiplication at two *kebeles*. Akako and Denkaka, of Ada'a *woreda* are presented in Table 1.

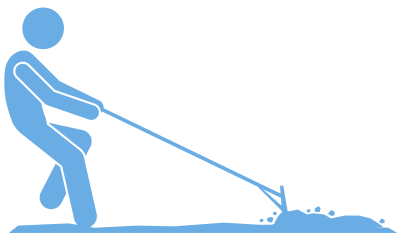
Seed system: Good-quality seeds, along with yield-enhancing technologies, are vital for increasing lentil production and improving farm household livelihoods. To scale lentil innovations, strengthening a robust seed system has become a strategic priority. Establishing early-generation seed production schemes at research centres and fostering collaboration with stakeholders are essential elements for ensuring a sustainable supply and access to certified seeds. The number of farmers producing lentils in Ada'a woreda has declined significantly because of lentil diseases and the lack of seeds of improved lentil varieties. A few farmers were struggling to cultivate lentils using low-yielding and disease-susceptible old varieties. Generally, there is a weak seed replacement and supply system for lentils in the country in general and Ada'a woreda in particular.

To ensure a sustainable supply of lentil Early Generation Seeds (EGS), linkages were created between research centres and seed-producing farmer groups during lentil demonstration trials in 2023, while also supporting experienced private seed producers.

Table 1. Yield (both grain and straw) performance of Baredu variety seed multiplication in comparison with local/farmer's variety in two kebele during the 2023 season.

Kebele	Varieties			
	Baredu (improved variety)		Local variety	
	Grain yield (t ha-1)	Straw yield (t ha-1)	Grain yield (t ha-1)	Straw yield (t ha-1)
Akako	1.43	4.92	1.04	4.86
Denkaka	1.34	4.71	1.17	5.08
Total average	1.4	4.81	1.09	4.97

Seedbed preparation: To improve soil health and optimize crop production, farmers were advised to plough their land 2-3 times depending on the soil type and weed condition. The first ploughing should occur during the short rainy season (March to May), followed by the second ploughing in mid-June and the third in early August. Farmers were also advised to use land for lentil cultivation which was free from legume crops in the past 2-3 seasons to break potential disease cycles.

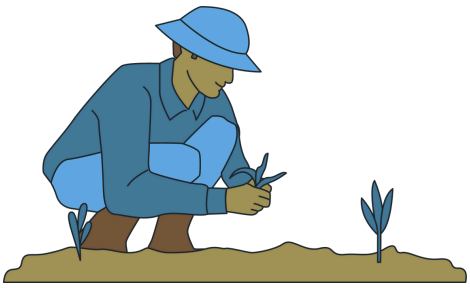


Recommended method: *2-3 times depending on the soil type and weed condition*

Seed rate: Generally, the seeding rate for lentils depends on the seed size. The recommended seed rates are 50-65 kg ha^{-1} for small-seeded varieties, 65-80 kg ha^{-1} for medium-sized varieties, and 100-120 kg ha^{-1} for large-seeded cultivars. For the two lentil varieties Baredu and Furi, the recommended seed rate is 70 kg ha^{-1}.

Recommended rate: 50-65 kg ha^{-1} for small, 65-80 kg/ha for medium, and 100-120 kg ha^{-1} for large-seeded cultivars

Seed dressing: Dressing seeds with Apron Star (a mixture of thiamethoxan, metalaxyl-M and difenoconazole) to manage and reduce seedling damage caused by fusarium wilt and root rot diseases.



Recommended bacteria: *rhizobial inoculum EAL-600 can increase lentil yield by 21%*

Use of inoculum: Like other legumes, lentil requires less nitrogen (N), as it can fix N from the atmosphere through Rhizobium bacteria. Therefore, inoculating lentils with Rhizobium is recommended to reduce the application of inorganic N fertiliser. The rhizobial inoculum EAL-600 can increase lentil yield by 21% (Gebrekidan et al., 2019). It is recommended to complete seed dressing with Apron Star 2 to 3 days in advance. Once this process is done, the rhizobium inoculum should be applied just before planting/sowing to ensure optimal effectiveness and also avoid the toxicity of this fungicide to the rhizobium.

Sowing method: Row planting was implemented with a spacing of 5 cm between plants and 20 cm between rows.

Fertilizer rate: 100 kg ha^{-1} NPS is recommended using broadcasting method where this kind of fertilizer is spread evenly across the field at the time of sowing.

Recommended fertilizer rate: *100 kg ha^{-1} NPS*

Planting date: The planting date for lentil varies from place to place depending on the area's soil type and precipitation. In the case of Ada'a *woreda*, the first week of July is the recommended sowing date for lentil. This is relatively late and will help to reduce the damage caused by pests such as root rot, rust, pea aphids, and waterlogging. Generally, fields with good drainage are planted very early; and fields with poorer drainage are planted late.

3.3 Crop protection

Common pests and diseases affecting lentils: Lentil diseases such as Ascochyta blight (*Didymella lentis*) and Fusarium wilt (*Fusarium oxysporum f.sp. lentis*), lentil viruses like Pea Seed Borne Mosaic Virus (PSBMV), and insect pests such as the pea aphid (*Acyrthosiphon pisum*) were the major pests observed in lentil trials. The above-mentioned pests and diseases all affect lentil yield and quality.

Figure 3. Symptoms of lentil fusarium wilt (Photo credit: Asrat Zewdie).

Figure 4. Ascochyta blight symptoms on lentil (Photo credit: Asrat Zewdie)

Figure 5. Lentil Pea Seed Born Mosaic Virus (Photo credit: Asrat Zewdie)

Integrated Pest Management (IPM): To address the aforementioned pest problems, the following IPM practices were applied, grouped into monitoring, agronomic practices, cultural practices, biological control, and chemical control measures whereby the use of pesticides should be avoided as much as possible or only be used minimally.

Monitoring

Scouting: It was conducted for different diseases and insect pests during lentil production at various growth stages until harvest. After scouting the fields, if symptoms of lentil Ascochyta blight, Fusarium, or damage from pea aphids were observed, decisions were made to prevent or control the spread of diseases and insect damage through the application of fungicides and insecticides, provided the pest levels were at or above the economic threshold (for example, for aphids, when the count of aphids within a 1 cm^2 area is about 10-15); however, for aggressive and polycyclic diseases such as *Ascochyta blight* and rust diseases, application of pesticides should be made as soon as the disease appears.

Agronomic practices

Hygiene: The use of high-quality, clean seeds and a field free of preceding crop residues such as straw that may harbour malignant spores are recommended.

Tolerant varieties: Different levels of tolerance exist among lentil cultivars, specifically *Baredu* and *Furi*, Cultivars are moderately tolerant to soil-borne diseases, pea seed-borne mosaic viruses, and Ascochyta blight disease (Table 2).

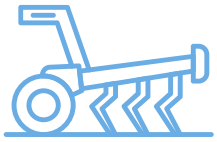
Table 2. Disease reactions of the Baredu and Furi to major lentil diseases

Variety	Ascochyta blight*		Rust*		Wilt/root rot (Fusarium)**	
	Scale	Disease tolerance	Scale	Disease tolerance	Scale	Disease tolerance
Baredu	5	S	-	-	3	R
Furi	4	MR	3	MR	3	R

***Key:** Ascochyta blight and Rust scoring scale (1-9) rating scales (Pande et al., 2006)
1 = asymptomatic (A);
1.1-3.0 = resistant (R)
3.1-5.0 = moderately resistant (MR)
5.1-7.0 = susceptible (S)
7.1-9.0 = highly susceptible (HS)
****The level of resistance/tolerance of lentil varieties to Fusarium
1 = Asymptomatic (0 % plants wilted),
2-3 = Resistant (0-10% plants mortality)
4-5 = moderately resistance (10.1-20% mortality)
6-7 = susceptible (20.1-40% mortality) and
8-9 = highly susceptible (more than 40% mortality) for wilt/root rot (Fusarium) (Damte and Tafes, 2023)

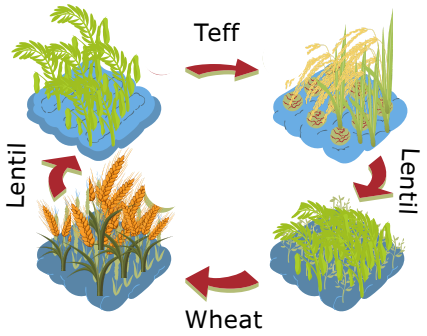
Cultural measures

Tillage: Weed control in lentil production can be managed through proper land preparation, such as using proper tillage practice, i.e., conventional tillage practices (plough land 2-3 times depending on the soil types).



plough land 2-3 times depending on the soil types

Crop rotation: As mentioned, pest and disease infestation can be managed to a certain degree through crop rotation. Lentil was rotated with cereals such as teff and durum wheat for three years during the trial. The rotation with non-hosts of Ascochyta blight reduces the primary source of inoculum level. This is not applicable for soil-borne diseases due to the ability of some of the pathogens to survive for more than six years in the soil, in the absence of a host.



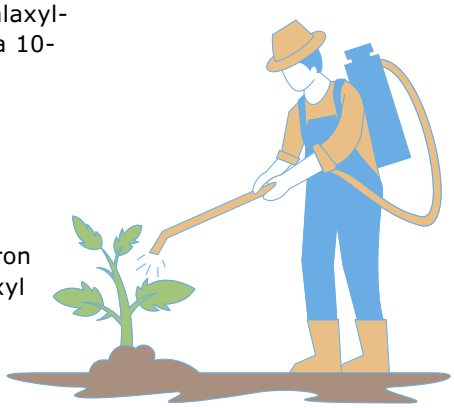
Hand weeding: This practice is an effective means of control, if it is carried out at an early stage but this is often delayed until the weeds are large enough to be grasped by hand, by which time they are already competing with the crop.

Figure 6: Lentil agronomic practices at Bishoftu research station together with Mr. Gadisa Lelisa (Lentil Breeder) (Photo Credit: Asfaw Zewdu)

Chemical control

Fungicides

Ascochyta blight: Ridomil Gold MZ WG (active ingredients (a.i.) metalaxyl-M 4% + mancozeb 64%): applied at 2.5 kg ha^{-1}, with two sprays at a 10-day interval.



CAUTION: mancozeb is listed as having potentially long-term health effects according to the PAN International List of Highly Hazardous Pesticides (PAN, 2024)

Seed- and soil-borne diseases, including wilt/root rot complexes: Apron Star 42 WS (a.i. thiamethoxam 20% + ditenoconazole 2% + metalaxyl 20%): applied as seed dressing at 2.5 g/kg of seed.

CAUTION: thiamethoxam is highly toxic to bees (PAN, 2024)

Insecticides

Highpyro 220 EW (a.i. lambda cyhalothrin 2% + chlorpyrifos 20%): Applied at 0.8 L ha^{-1}, with two applications targeted at pea aphids during the vegetative and flowering stages.

CAUTION: lambda-cyhalothrin can be fatal when inhaled (acute toxicity), and chlorpyrifos can influence the reproductive system (PAN, 2024)

Herbicides

Annual & perennial grasses: Gallant Super (a.i. Haloxyfop-R-methyl), a selective systemic post-emergence herbicide, applied once at 300 ml ha^{-1}.

CAUTION: Haloxyfop-R-methyl is a potential carcinogen (PAN, 2024)

Precaution for pesticide application: Effective pesticide application for controlling pests should be carefully planned, and also adherence to best practices is necessary to ensure both efficacy and safety. Timing of pesticide application is crucial; pesticides should be applied at the right stages to avoid yield loss.

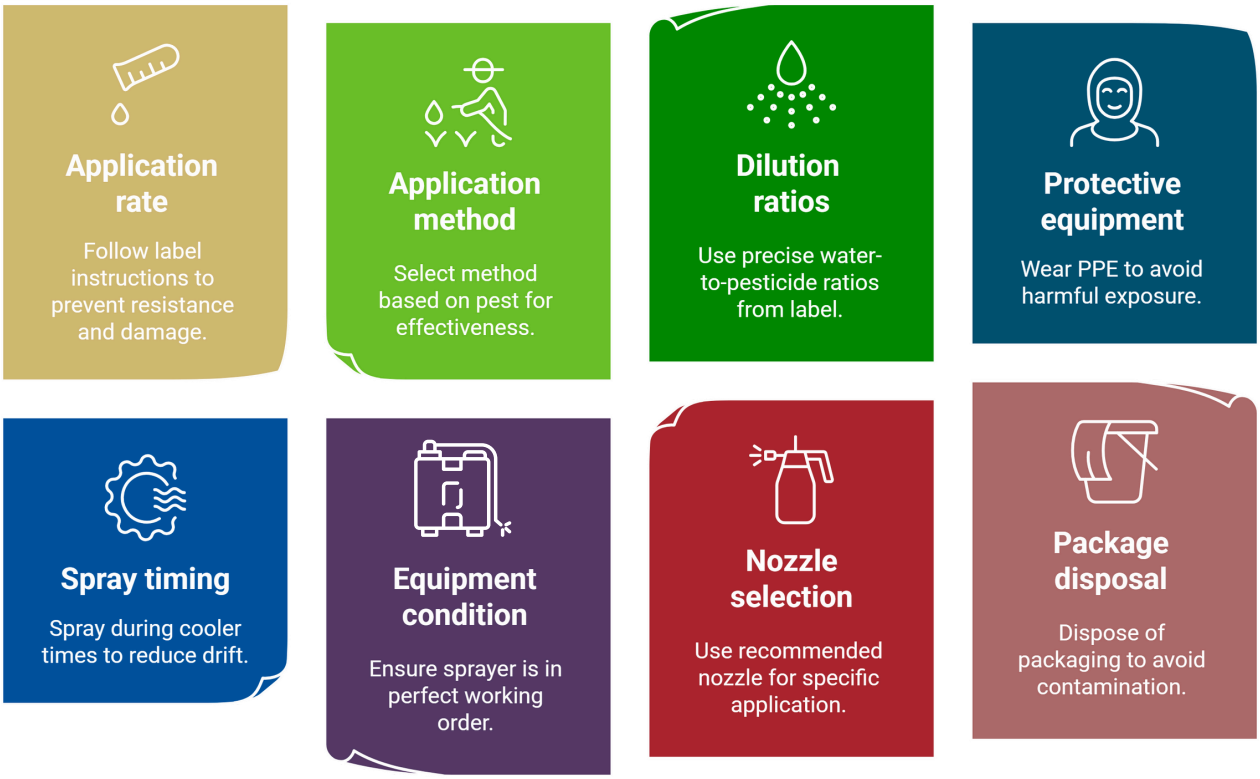


Figure 7: Pesticide application best practices for effective pesticide application for controlling pests

3.4 Post-harvest management

Harvesting and Threshing: Lentils typically mature within three and a half months. Lentil harvesting is optimally done when approximately 80-90% of the pods have turned yellow to light brown, indicating that the seeds are firm and have reached physiological maturity. At this stage, the moisture content of the seeds is around 14-16%, which is suitable for harvesting without significant losses due to shattering or excessive moisture. Careful monitoring is essential to prevent pod shattering, which causes losses. It is recommended that harvesting should take place during the cooler, more humid parts of the day to preserve moisture. It is recommended that harvesting should be done by only removing the above-ground part of the lentil and leaving the roots of the lentil in the soil. However, farmers usually harvest lentils manually by pulling the entire plant from the land. After harvesting, it is necessary to dry, pile, and then thresh, either by beating with a stick or driving oxen over the heaps. Timely harvesting at this maturity level ensures good seed quality and reduces post-harvest losses. Delaying harvest can lead to increased shattering and potential yield loss, while premature harvesting may result in immature seeds of lower quality.

Storage: Lentil is usually stored in locally constructed storage facilities. More attention should be given to avoid losses during storage due to storage lentil pests such as Adzuki bean beetle (*Callosobruchus chinensis*). The lentil grain should be stored at a proper moisture level (12-14%) to reduce the beetles as well as loss due to contamination with mycotoxin. In general, lentil grain should only be stored if it is clean and dry; grain must be maintained at low temperatures and moisture content for maximum storage time.

3.5 Productivity

Yield: The demonstration results indicated that improved varieties *Baredu* and *Furi* yielded 1.46 and 1.34 t ha^{-1}, respectively, compared to 1.02 t ha^{-1} from the local variety at Ada'a woreda (Table 3). The yield advantages of the improved varieties Baredu and Furi were 43% and 30.5%, respectively, when compared to the local check. Moreover, the mean yield from scaling activity in 2024 of *Baredu* and *Furi* varieties in Ada'a and Gumbichu woredas are 1.37 and 1.57 t ha^{-1}, respectively (Table 4).

Table 3. Yield advantages of improved varieties compared to local practice at two kebeles of Ada'a woreda on twenty farmers' fields in 2023.

Varieties	Year of release	Maintainer	Demonstration Kebeles (t ha-1)		Average productivity (t ha-1)	Yield advantage (%) over local practices
			Akako	Denkaka		
Baredu	2019	DZARC	1.63	1.29	1.46	43
Furi	2021	DZARC	1.33	1.34	1.34	30.5
Local	-		0.8	1.25	1.02	-

Mean average yield data from 2024 scaling

Table 4. Lentil yields (t ha^{-1}) in Scaling lentil innovations in Ada'a and Gumbichu woredas in 2024

Varieties	Mean	N	Std. Deviation	Minimum	Maximum
Baredu	1.37	8	0.155	1	1.5
Furi	1.57	4	0.166	1.4	1.8
Total	1.44	12	0.182	1	1.8

Profitability analysis: The total variable costs (TVC) to produce the *Baredu* and local varieties are 53,212 ETB ha^{-1} and 51,812 ETB ha^{-1}, respectively. This means that the total variable costs (seed, fertiliser, pesticides, and labour) for producing the Baredu variety are higher than those for the local variety by 1,400 ETB per hectare. This difference may indicate varying inputs, such as seed, fertilizers, or labour costs associated with each variety, impacting the overall production expenses. The total revenues from Baredu and local varieties are 224,774 ETB ha^{-1} and 171,704 ETB ha^{-1}, respectively. This means that the total revenues generated from producing the Baredu variety is significantly higher than those of the local variety, which is about 53,070 ETB per hectare. This suggests that the Baredu variety is more profitable due to its higher yield and superior quality as compared to the local variety. The net profit obtained from the Baredu variety production is 171,563 ETB ha^{-1}, while for that of the local variety, it is 119,891 ETB ha^{-1}. . This indicated that the Baredu improved variety has a profit advantage of 51,671 ETB ha^{-1} over the local varieties (Table 4). However, the local variety outyielded the *Baredu* variety in terms of straw yield.

Farmer preferences: Farmers actively participated throughout the intervention process, playing a key role in evaluating the demonstrated lentil varieties based on traits they deemed important. Each farmer established their own selection criteria, ranked the traits according to their preferences, and compared the improved varieties with the local ones. This preference ranking process included both male and female farmers. While some differences in trait preferences were observed between men and women, both groups ultimately preferred the improved varieties, Baredu and Furi, over the local variety (Table 5).

Table 5. Trait ranking and preference of women farmers for different lentil varieties during technology evaluation trail

Rank of traits	Traits	Varieties ranked by women farmers				Varieties ranked by men farmers			
		Baredu	Furi	Derso	Local	Baredu	Furi	Derso	Local
1	Disease tolerance	1	2	4	3	1	3	4	2
2	Number of pods	1	2	4	3	1	3	4	2
3	Seed size	1	2	3	4	1	2	3	4
4	Grain colour	1	1	3	4	1	2	3	4
5	Cotyledon colour	2	1	1	2	1	1	3	4
6	Yield/biomass	-	-	-	-	1	2	4	2
7	Uniformity	-	-	-	-	1	2	3	4
Overall ranks of varieties		1	2	3	4	1	2	4	3

A sensory test was conducted to compare consumer perceptions of the *Furi* and *Baredu* lentil varieties. Twenty participants, consisting of 10 male and 10 female farmers from the Denkaka *kebele* of Ada'a *woreda*, were asked to select their preferred lentil stew. The data collected from the two groups were analysed separately.

The results showed that both the whole and split *Furi* variety stews were slightly preferred over the *Baredu* variety. There was no significant difference in preference between the split lentil varieties among either the female or male panellists. However, the whole lentil stew made from the *Furi* variety is preferred over the *Baredu* variety. Notably, the female participants favoured the *Furi* variety more than the male participants, which may be attributed to their familiarity with constituting food processing in the area's culinary practices.

3.6 Marketing and employment opportunity

Lentils present a promising market opportunity. According to key informant interviews in Sendafa, the price of lentils was 140 ETB kg^{-1} in 2023, while by 2025, it had risen to 270 ETB kg^{-1} This significant price increase over two years indicates a growing demand for lentils in the market.

In the Sendefa Beke area, lentil processors have created job opportunities for 100 to 150 individuals per processing company. However, due to a decrease in lentil production, this number has dropped to about 40 laborers per day. These processors engage in various post-harvest activities, including cleaning, drying, sorting, peeling, splitting, packaging, and market distribution. To enhance value addition, create more job opportunities, increase income, and better meet consumer demand, it is essential to boost lentil production and supply for these processors.

3.7 Nutrition and safety

To enhance awareness of the nutritional value and safety of lentils, complementary interventions were carried out in Akako and Denkaka *kebeles* of Ada'a woreda, focusing on both training and capacity building for farming households and other local stakeholders. These trainings targeted farmers along with their spouses, DAs, and *woreda*-level officials, including those from the health and agriculture offices.

The trainings provided insights on the nutritional benefits of consuming lentils, such as their high protein content and essential micronutrients like iron and folate, which are vital in combating malnutrition. Additionally, these awareness-raising sessions emphasised the role of lentil in improving dietary diversity, particularly in this area where cereals dominate people's diets.

Food safety topics, related to proper postharvest handling, storage, and pest control of lentils, were also addressed to ensure that lentils not only remain nutrient-rich but also safe for consumption.

Consumption of lentils can contribute significantly to healthy diets. It is significantly important that the woreda experts who engage with farming households to produce and scale lentil production also work on awareness creation and disseminating information about the nutritional value of lentils in households' diets.

3.8 Enabling environment

Several capacity-building activities were provided to both implementing and scaling partners to enhance institutional capabilities related to lentil innovations.

These activities included

- Raising awareness and sensitizing stakeholders on food systems concepts and approaches,
- Promoting gender awareness through various gender transformative tools (GTAs) with the goal of fostering gender transformation,
- Nutrition awareness and the role of lentils in a healthy diets,
- The concept of food safety and consumption of safe food in healthy diet,
- Create awareness on nutrition-sensitive agriculture practices and,
- Scaling readiness concepts and approach
- Organizing field days and experience-sharing (Figure 8)
- Developing mechanisms to increase production volumes of quality seed

Figure 8. Lentil field day organized at Denkaka kebele during 2022 cropping season

3.9 Gender equality and social inclusion

To promote inclusivity, farmers from diverse social, economic, and geographical backgrounds were engaged in the lentil innovation process. The aim was to include farmers from both wealthier and poorer backgrounds, as well as those who were socially isolated or geographically less accessible. These farmers participated as both host and follower farmers.

Gender equality and social inclusion have been taken into consideration in the validation, demonstration, and scaling of lentil innovations. Throughout the participation of farming households in various activities, we encouraged representation from different age groups, including youth, adults, and elders, as well as both women and men (couple approach). Accordingly, 223 men and 125 women actively participated in the lentil innovation activities. Among these participants 11 of them were youths.

Various activities were organised, including training sessions, participatory variety selection (PVS), technology evaluation, field day events, and cooking demonstrations. Throughout these activities husbands and wives or couples were involved. Such approaches were implemented to challenge the inequalities between women and men in household decision making and division of labour and in accessing opportunities. In complement, training on gender equality and social norms was also provided to address underlying gender disparities and social norms. By offering this training alongside sessions on lentil agronomy, crop protection, seed production and nutrition, participants could directly see how addressing gender inequality supports them to take up these technical aspects.

Women's decision-making in lentil innovation is gathered from host farmers during both the demonstration stage, involving 20 farmers, and the scaling stage, involving 12 farmers (Figure 8). Data were collected from a sample of host farmers using an interview schedule aligned with the lentil production calendar at various intervals. This decision-making encompasses several key aspects: selecting which crops to grow and the specific locations on the farm, determining the inputs and labour required, and deciding on the frequency and timing of weeding, harvesting, and threshing.

Market-related decisions include when and who is responsible for taking crops to the market, whether to sell or retain the produce, when and to whom to sell, and how to set prices. Decisions regarding income use and control relate to how earnings from lentil production are allocated, covering aspects such as purchases, expenditures, and savings. Lastly, consumption decisions involve determining how much to consume or sell, the quantities used for cooking, and the frequency of eating lentil-based products.

The couple approach and other training initiatives contributed to promoting women's decision-making in lentil production, marketing, income control and use, and consumption. It is advised that women and their husbands engage together in planning, implementation, training, field days, and other lentil value chain activities. This indicates that lentil innovation would be less effective if approached in a gender-blind manner, such as targeting only men for training and interventions, despite women contributing significantly to farm work.

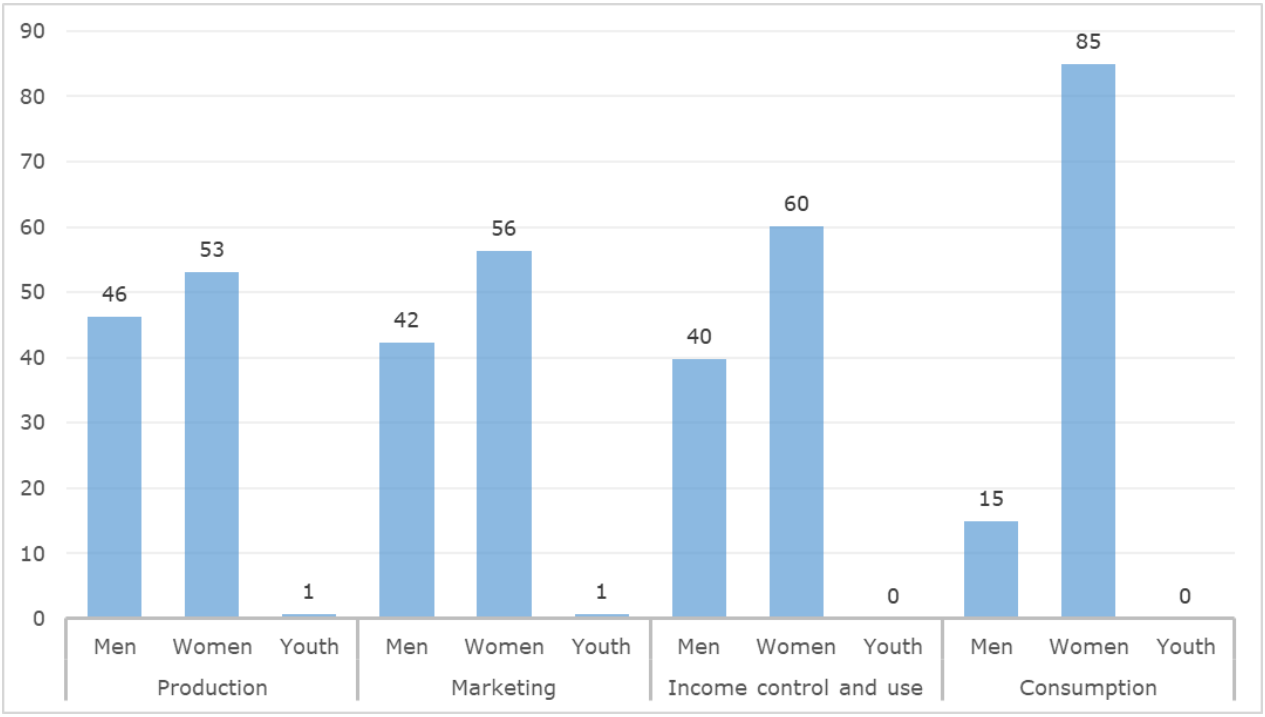


Figure 9. Percentage of household members participation in decision-making in lentil innovation in Ada'a and Gumbichu woredas.

4.Lesson learned

From validation, demonstration and scaling of lentil innovation in Ada'a and Gumbichu *woredas*, the following lessons were learnt to facilitate broader adoption of lentil innovation for contributing to food system transformation in the areas.

Evidence-based bottom-up planning: the bottom-up approach, which emphasises identifying key challenges, opportunities, and leverage points, is essential for revitalising lentil production. Engaging research institutions and local stakeholders, including farmers, has facilitated the co-creation of critical challenges and practical solutions related to lentil innovation.

Promoting innovation bundles: implementing comprehensive bundles of innovation within a food system framework effectively addresses systemic issues that contribute to revitalising lentil production and utilisation and enhancing food and nutrition security. Key elements such as gender inclusion, nutrition, integrated pest management (IPM), proper drainage, and strong stakeholder collaboration are crucial for addressing the interconnected challenges of lentil innovation.

Increase seed multiplication efforts to meet growing demand: In 2024, lentil innovation scaling efforts included 60 farmers across four kebeles in Ada'a and Gumbichu *woredas*, with highly promising results. Consequently, a significantly larger number of farmers have expressed interest in participating in lentil production next year. To meet this demand, it is essential to increase seed multiplication efforts to ensure an adequate and timely supply of high-quality lentil seeds for expanded cultivation. This proactive measure will support the sustained growth of lentil farming in the area and prevent bottlenecks in seed availability.

Strengthen Integrated Pest Management for Sustainable Production: Lentil diseases continue to present a challenge for sustainable cultivation. To address this, a comprehensive, integrated disease management approach should be maintained, focusing on effective cultural practices, regular field scouting, and agronomic techniques that reduce the potential for disease incidence. Besides, research institutions should prioritise developing lentil varieties with durable resistance to multiple diseases, which will be critical to achieving resilient and productive lentil crops. This focus on disease-resistant varieties will help ensure that lentil farming remains viable and beneficial for the farmers in the area.

Importance of Capacity Building: Capacity-building activities are essential for implementing and scaling partnerships, as they enhance institutional capabilities related to lentil innovations.

Gender Equality and Social Inclusion: Gender equality and social inclusion are crucial factors in the generation and dissemination of lentil innovations.

Enhance Multi-level Stakeholder Support for Scaling Efforts: Effective scaling of lentil production requires ongoing commitment from stakeholders at multiple levels. Kebele, woreda, and regional stakeholders and Bishoftu Agricultural Research Centre have already shown strong support for expanding lentil cultivation based on the 2024 season's positive results observed during the field day event. Continued collaboration of these stakeholders will be essential for further scaling efforts, both within Ada'a and Gumbichu woredas and also in similar areas seeking to revitalise lentil farming.

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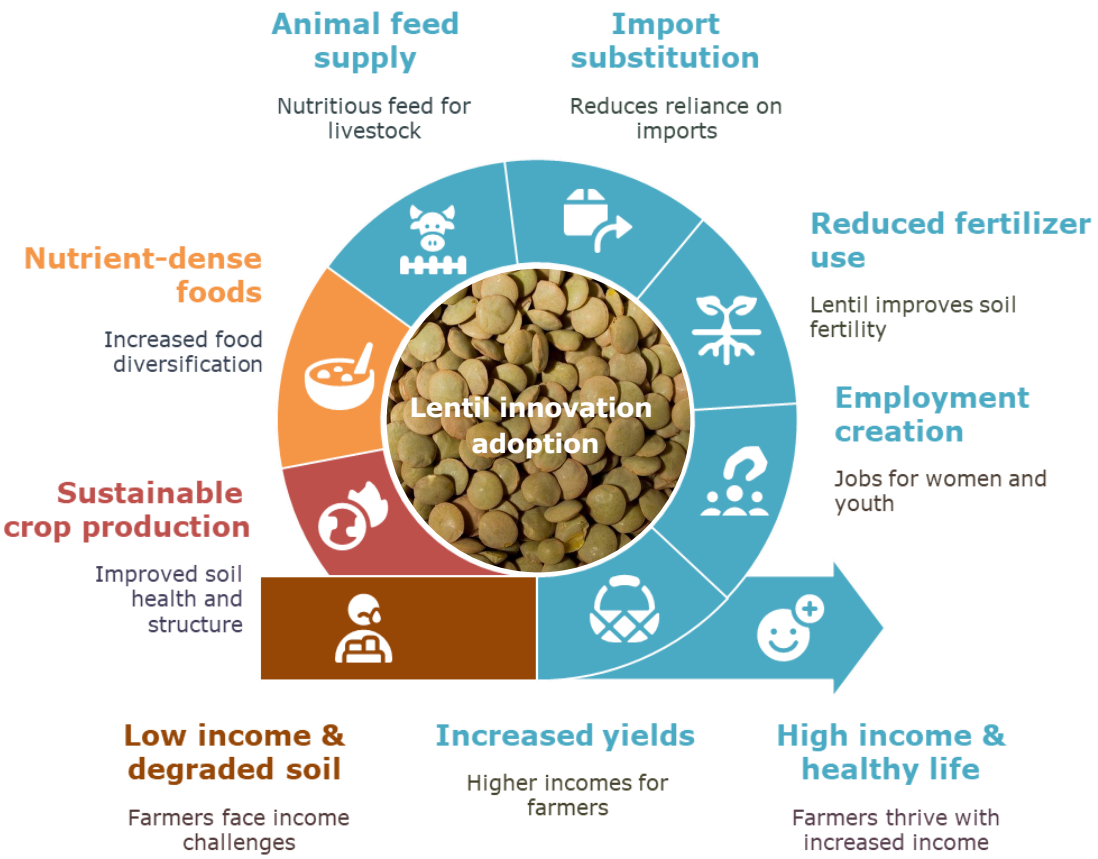
Contribution of lentil innovations to food systems transformation

The adoption of lentil innovations has significantly contributed to food systems transformation by improving socio-economic, health, and environmental outcomes. It has significantly contributed to transforming food systems by increasing farmers' incomes through higher yields and market demand, creating on-farm and off-farm employment opportunities, particularly for women and youth, and reducing expenses on chemical fertilisers by enhancing soil fertility through nitrogen fixation. Lentils also contribute to import substitution, export opportunities, and reduced animal feed costs, improving livestock productivity. Nutritionally, it enhances the availability of nutrient-dense foods and promotes food diversification. Environmentally, lentils improve soil fertility, structure, and moisture retention while supporting sustainable crop production through crop rotation systems.



Lentil innovation contribution for socio-economic, health, diet and environmental outcomes

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