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STRENGTHENING THE COMPETITIVENESS OF THE LENTIL SEED SYSTEM OF NEPAL: A VALUE CHAIN APPROACH

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Abstract. A value chain approach is the most viable and pragmatic strategy to develop an effective, inclusive, competitive and sustainable seed system for many crops globally. This study was conducted in the Kailali, Dang and Siraha districts of the Terai and Inner Terai regions of Nepal to map and thoroughly analyze the value chain of the lentil seed system. Primary data were collected through a household survey, key stakeholder interviews and focus group discussions. Altogether, 300 lentil grain-producing and 100 seed-producing farmers were selected for the study. Descriptive statistics, value chain mapping, stakeholder price spread calculation and return on investment were the major tools for the study. Conventional cultivation practices along with incidence of biotic and abiotic stresses ensured non-significant differences in yield, income and benefit-cost ratio (B:C) between local seed users and improved seed users, resulting in a distorted demand pull chain and eventually leading to the lamentable lentil seed system. Total value addition from farm gate to end user was 63.84% of the total retail price. Seed conditioners and processors contributed 28.38% of total value addition. Return on Investment (ROI) per total cost was higher for seed-producing farmers (59.3%). However, ROI per added cost was higher (214.8%) for retailers followed by seed conditioners and processors (96.37%). The total price spread along the chain was 45.21% of the total consumer price, revealing the inefficient marketing system. Scaling up the major factors behind improved seed adoption, like package of practices, use of a specialized production area, the development of stress resilient varieties, technical assistance, training, and subsidy schemes based on production and efficient market system development, can economically benefit lentil-producing farmers, thereby reinforcing the major pulling force of the lentil seed value chain. Appropriate infrastructure, government prioritization, a coordinated policy environment and innovative public-private partnership models across the seed value chain are necessary for overall sectoral growth.

Keywords: Lentil, seed system, value chain, government prioritization, governance

INTRODUCTION

Legumes are a major source of dietary protein and essential nutrients, especially for poor families in developing countries like Nepal, who cannot afford expensive animal proteins. Legumes provide up to 20–25% of protein by weight, which is 2–3 times that of wheat and rice (Shahwar et al., 2017). In cereal-based cropping systems, lentils occupy a unique position among legume crops in terms of their capacity to improve human, animal and soil health (Erskine et al., 2009). The higher protein content and insignificant levels of cholesterol, fat and anti-nutrients found in lentil cotyledon are

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credited with making it the foremost preferred protein source for human consumption (Sultana and Ghafoor, 2008). Whole lentils contain 25.8% protein while split lentils contain 25% protein (Kim et al., 2016). As well as having a high protein content, lentils are a major source of minerals, vitamins and lipids. They have numerous potential health benefits, such as anti-carcinogenic, blood pressure-lowering, hypo-cholesterolemic and glycemic-load-lowering effects (Faris et al., 2013). Because of their high calorific value and plentiful nutrient load, lentils are considered a major component of the food and nutritional security of rural smallholder households in developing countries like Nepal.

Lentils are cultivated across all provinces in Nepal. In terms of agro-climatic zones, lentil cultivation is concentrated within the Terai region, with a share of more than 95% of total production. The total cultivated area, production and productivity of lentils are 212,000 hectares, 262,000 tonnes and 1,256 kg ha^{-1} respectively (MoALD, 2021). Lentil cultivation in Nepal accounts for 4.2% of the worldwide area devoted to the crop and 4.02% of global production. However, the productivity of lentil cultivation in Nepal is 5.36% below global productivity (FAOSTAT, 2022). Lentils from Nepal constitute only 3% of the total world market for lentils (ITC, 2019). Lentil production has been seen to change over time in prior years. However, from 2013 to 2015, production remained unchanged. The total production of lentils in 2016 was almost 11% higher than in 2015 (MoALD, 2020). In recent years, the total demand for lentils in Nepal has increased. During the year 2020, the total national demand for lentils was 359,000 tonnes, which is 37% higher than in 2015 (MoALD, 2020). Due to changing consumption patterns, increased health awareness and an increasing population, the demand for lentils will increase rapidly in the near future and will reach 390,000 tonnes in 2025 (Thapa et al., 2019). Currently, total national production covers only 71.2% of total national demand. Increasing domestic demand and decreasing production have combined to cause a ballooning trade deficit. In 2020, total lentil imports were almost 24 times higher than total national exports (MoALD, 2021). To meet domestic national demand and realize the foreign trade potential of Nepalese lentils, the total cultivated area, production and productivity of lentils must be extended in the near future.

Low productivity in agriculture is the result of reduced use of better-performing varieties, poor quality seeds and other inputs (fertilizer, irrigation, farm machinery, etc.) and production technologies (Gauchan, 2019). The use of quality seeds only can increase crop yields by up to 40–45% (Abebe and Alemu, 2017; Panta, 2015; Wimalasekera, 2015). The use of improved seed not only increases crop yield but also enhances the efficiency and productivity of other inputs like fertilizer, irrigation, farm machinery and human labor, ultimately helping sustainable crop production. The replacement of previous low yielding varieties and poor quality seeds with better quality seeds and improved varieties is thus a more meaningful and practical measure for increased production (Spielman and Kennedy, 2016). However, the majority of Nepalese farmers have been using locally saved and exchanged seed for many crops for many years. The present seed replacement rate of major crops is less than 15% and it is below 5% for lentils (SQCC, 2017). This scenario does not ensure farmers' access to quality seeds of a wide range of varieties of lentil. The provision of improved quality seed in sufficient quantities, on time, and with accessible and appropriate varietal options is crucial to promote the adoption of improved varieties and close the yield gap.

Efficient and sustainable seed systems can help to improve the livelihoods of small farmers, serving as an important element in strategies for agricultural development and poverty reduction (Mulugeta et al., 2010). The availability of seed of improved varieties among lentil growers largely depend on a strong competitive lentil seed value chain with an efficient and wide distribution network (ANSAB, 2011). To date, only 14 lentil varieties are available for seed production and trading (MoALD, 2022). Many public and private organizations are working on lentil seed-related business with the support of NGOs and INGOs. Government organizations are there for quality control and policy formulation, and externally the lentil seed system seems to work in an efficient, sustainable and holistic way, but actually deep issues exist, as is reflected by the lentil seed replacement rate of less than 5% (SQCC, 2017). Nepalese farmers are less willing to pay for improved seed varieties (Mishra et al., 2017), and thus studies on farmers' valuations of current improved lentil varieties, their attributes, the types of services they are willing to pay for, and factors affecting the adoption of improved lentil varieties are very scanty in Nepal. On the side of seed supply, federal transformation has created structural and legal dilemmas along with weak coordination among the three tiers

of the government system, and hindered the seed multiplication process. During 2019, the demand for lentil breeder seed was 1,350 kg, production was 1,501 kg, and only 854 kg was distributed for seed multiplication. In the same year, production of lentil foundation seed was 10,888 kg while demand was only 1,597 kg and only 912 kg was distributed (SQCC, 2019). Likewise, tonnes of improved seed remained in storage and were finally sold as grain. As the lentil-growing farmers are the end users and the major pull factor of the overall lentil seed value chain, if they are not absorbing the available supplies from the market, the lentil seed value chain cannot function properly. This is directly linked with farmers' willingness to pay and their satisfaction levels with the improved lentil seed varieties available on the market, the preferred attributes of the varieties, and other reasons related to availability, timeliness, accessibility, technology and suitability (KUBK, 2017).

The availability and accessibility of improved seed varieties among lentil growers largely depend on a competitive, sustainable and efficient lentil seed value chain. To know the functioning of seed value chain, it is necessary to identify the operators, service providers and their respective activities. The analysis of linkages between value chain operators allows for a better understanding of the functioning of the seed chain (Bélanger et al., 2013). The regular system of research on farmers' preferred attributes, the temporal and spatial dynamics of such preferences, the constraints on the market and marketing system, resource use in lentil production and barriers to the adoption of improved lentil varieties is important for the design of upgrading interventions and to make such value chains competitive (Collins, 2009). The study analyzes the level of market orientation in product development, value addition and distribution. Likewise, it identifies the reasons for inefficiencies and potential leverage points for improving the performance of the chain to enhance the competitiveness and sustainability of the overall lentil seed value chain. This study thoroughly analyzes the strengths and weaknesses in every node of the lentil seed value chain, addressing varietal development, seed multiplication, seed production, quality maintenance, key actors in the lentil seed value chain, the marketing system and the upgrading of the lentil seed value chain. Market chain efficiency and sustainability can be ensured by correcting weak areas and adopting the strengths of the key actors in the lentil seed value chain. The growth of lentil seed commercialization can thereby be accelerated to create an inclusive, competitive and sustainable lentil seed system in Nepal.

METHODOLOGY

Study area

Among all the lentil-producing districts of Nepal, the top six are Dang, Kailali, Rautahat, Bardiya, Siraha and Bara. These districts account for 58.52% of the total lentil production and 47.27% of the total area used to cultivate lentils in Nepal (MoALD, 2020). Among those districts, Kailali, Dang and Siraha were selected for this study. To analyze the current situation and functioning of foreign trade, data from potential foreign exporters from districts like Rupandehi, Banke and Bara were also collected.

Sampling method and sample size determination

Using Cochran's formula, 150 lentil grain-producing farmers using local seed, 150 lentil grain-producing farmers using improved seed and 100 lentil seed-producing farmers were selected from the study districts. Primary data were collected using simple random sampling, snowball sampling and purposive sampling techniques through a pre-designed questionnaire, while secondary data were collected from secondary sources. For the detailed value chain analysis, 15 input suppliers, 15 seed collectors and processors (including large seed companies and small farmer's groups), 15 retailers, and all the service providers of the respective districts were selected. A total of six focus group discussions were carried out to cross-validate the household survey data.

Lentil seed value chain: mapping and analysis

Before value chain analysis, different functions, actors and service providers along with their functional relationships were mapped. This mapping shows the flow of transactions from the sourcing of raw materials and inputs to production, processing, marketing and final sale of lentil seed. The mapping of the lentil seed value chain includes costs, value addition, price enabling environments, critical constraints and the relative clout of the players. In this study, each node of the value chain, from variety development, multiplication, processing, packaging, trading and distribution to the end users of the lentil seed, was critically examined. Flow of cost, value

addition, margin, return on investment and price spread were also calculated throughout the chain.

Production and marketing problems

Based on the response frequencies, an indexing technique was used to identify major problems with production and marketing. Those problems were ranked using a five-point level of influence comprising most serious, serious, moderate, low, very low or no problem at all, using scores of 1.00, 0.80, 0.60, 0.40, 0.20 respectively. The priority index for each variable was calculated as a weighted average in order to draw valid conclusions and make responsible decisions. The index of influence was calculated using the following formula:

$$I_{inf} = \sum \frac{s_i f_i}{N}$$

Where, I_{inf} = index of influence, Σ = summation, s_i =scale value, f_i = frequency of influence given by respondents, N = total number of respondents

Descriptive statistics like the t-test and Chi square test was used for the analysis in the Stata/SE 12.1.

RESULT AND DISCUSSION

Economics of lentil grain and seed production

Despite the increasing demand for lentils in Nepal, the study revealed a decreasing trend in production. However, the price of lentils has been increasing in recent years. In 2021, the average productivity of lentils using local seed was 568.8 kg/ha while it was 620.1 kg/ha using improved seed. The lentil yields of local seed users and improved seed users were statistically similar in the years 2019 and 2021 but this difference was statistically significant at the 10% level in 2020. Increasing demand but decreasing supply has caused the price of lentils to rise in recent years. The average price of lentil was NRs. 70.9/kg in 2019 and reached NRs. 85.5/kg in 2021.

For those farmers using improved seed, 33.6% of the total variable cost was accounted for by labor, 21.7% by seed, 21.4% by threshing and 11.1% by land preparation. For local seed users, 28% of the total variable cost was accounted for by labor, 10% by land preparation, 27.5% by seed and 18.2% by threshing. Likewise, for farmers who were involved in improved seed production, more than one third of the total variable cost (36.1%) was for labor followed by 25.2% for seed and 18.7% for threshing. Due to the higher labor requirements for processing, harvesting, and intercultural operation in seed production, the cost of labor was higher for seed producers than for grain producers. Analyzing the total variable cost and gross income from lentil grain and seed production, this study revealed a 23.6% higher cost for seed production than for grain production. However, revenue from seed production and grain production was statistically similar.

Table 1. Production (per hectare) and price trend of lentil grain in the study area

Variables	Overall (*n* = 300)	Local seed user (*n* = 150)	Improved seed user (*n* = 150)	Mean difference	t-value
			Total production (kg)		
2021	594.4 (301.4)	568.8 (321.9)	620.1 (492.8)	–51.3	–2.73
2020	537.8 (434.3)	507.2 (205.7)	568.4 (356.7)	–61.2*	–4.89
2019	664.5 (205.8)	656.6 (376.4)	682.5 (520.1)	–25.9	–2.21
			Price (NRs./kg)		
2021	85.5 (10.3)	82.2 (9.9)	88.8 (10.7)	–6.6	–2.1
2020	83.0 (9.2)	82.7 (8.4)	83.3 (9.7)	–0.6	–1.05
2019	70.9 (9.7)	70.8 (9.8)	71.1 (9.7)	–0.3	–0.67

Figures in parentheses indicate standard deviation. * Indicates significant difference at the 10% level.
Note: 1 USD = NRs.114.5
Source: field survey, 2021.

Table 2. Total variable cost and income (per hectare) from lentil grain and seed production

Parameters	Improved seed user		Local seed user		Seed producer	
	cost (NRs.)	share of total cost (%)	cost (NRs.)	share of total cost (%)	cost (NRs.)	share of total cost (%)
Labor cost	8 314.4	33.6	6 116.1	28	10 372.3	36.1
Land preparation cost	2 739.9	11.1	2 167.7	10	3 250.5	11.3
Seed cost	5 365.7	21.7	6 011.8	27.5	7 245.4	25.2
FYM, fertilizers and micronutrients cost	1 841.2	7.4	2 099.2	9.6	949.2	3.3
Disease and pest management cost	1 139.8	4.7	1 460.3	6.7	1 553.3	5.4
Harvesting, threshing and post-harvest cost	5 291.7	21.4	3 993.1	18.2	5 379.1	18.7
Total cost	NRs. 24 692.7		NRs. 21 848.2		NRs. 28 765.5	
Income from lentil production	NRs. 55 064.8		NRs. 46 755.3		NRs. 54 942.1	

Source: field survey, 2021.

For lentil grain and seed production, a large proportion of the total expenditure goes on variable cost items like seed, labor, land preparation and threshing. The study revealed that for improved seed users, local seed users and seed producers respectively, 66.7%, 64.43% and 83.3% of the total cost was for variable cost items (Table 3). Among improved seed users, the net profit was NRs. 29.6/kg, while it was NRs. 22.58 for local seed users. Likewise, the profit per kg from lentil seed production was NRs. 31.78, which is higher

Table 3. Cost-benefit analysis of lentil grain and seed production

Cost items	Improved seed user	Local seed user	Seed producer
1	2	3	4
Variable cost items	Cost per kg of lentil Grain production	Cost per kg of lentil Grain production	Cost per kg of lentil seed production
Labor	14.42	11.04	15.49
Land preparation (tractor/bullock)	4.42	3.81	4.17
Seed	9.65	10.57	13.02
Farm Yard Manure (FYM)	0.26	1.49	1.28
Urea	0.33	0.55	1.3
DAP	0.46	0.74	0.12
Micro nutrients	0.33	0.51	1.19
Disease/pest management	0.28	0.74	1.49
Threshing	9.31	8.02	6.61
Drying/processing	0.22	0.1	0.1
Total variable cost	39.68	38.41	44.76

Table 3 – cont.

1	2	3	4
Fixed cost items			
Land rent	11.33	13.54	4.64
Depreciation on farm equipment's	3.87	2.89	1.76
Repair and maintenance	4.31	4.78	1.35
Total fixed cost	19.51	21.21	7.75
Total cost	59.2	59.62	53.72
Average revenue per kg	88.8	82.2	85.5
Net profit per kg	29.6	22.58	31.78
B:C ratio over variable cost	2.23	2.14	1.91
B:C ratio over total cost	1.5	1.38	1.59

Source: field survey, 2021.

than for grain production. The overall benefit-cost ratio in lentil grain production was 2.18 for variable cost and 1.41 for total cost, while it was 1.91 for variable cost and 1.59 for total cost in seed production. This shows that lentil cultivation is a profitable business with good potential returns. The benefit-cost ratio was 13% higher for seed production than for grain production, implying that seed production is more profitable than grain production. A higher benefit-cost ratio has been reported in many other studies (Thapa Magar et al., 2014; Tithi and Barmon, 2018; Kumar and Bourai, 2012).

Major nodes of lentil seed value chain in the study area

Five main types of lentil seed value chain nodes were functional and found to be operating in the study area, led by private seed entrepreneurs and followed by public sector agencies, farmers' groups and cooperatives.

The lentil seed value chain in the study area starts with genetic resource collection and maintenance and extends up to the use of improved lentil seed varieties. Variety development and maintenance is mainly dominated by the public sector, especially by NARC. The private sector plays a dominant role in the quantity flow, followed by cooperatives, farmers group and the NSCL. Seed production is ultimately the task of contracted or non-contracted seed-producing farmers, and seems to be less organized and managed in the study area. Seed processing and conditioning are dominated by seed companies and cooperatives. The Grain Legume Research Program develops and maintains different varieties of lentil along with breeder and foundation

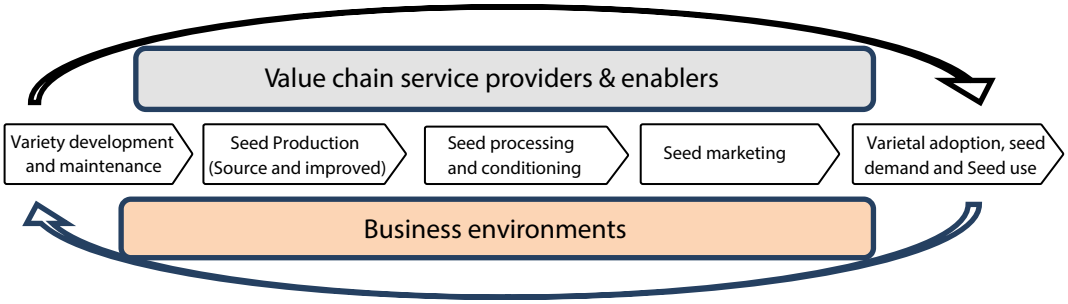

Fig. 1. Major nodes of the lentil seed value chain
Source: FGD & KII, 2021.

seed production. Breeder and foundation seed is then distributed to the private and public sector for further multiplication. There were no distinct and characteristic collectors. The collection of lentil seed was performed mainly by seed producing agencies. Varietal adoption and improved seed use was the most important driving force for the better performance of the overall chain. The stage of adoption of improved varieties of lentils, standard market assessment and information collection considering the positive and negative factors of adoption were the major factors to consider.

Flow of price, profit and value addition in the lentil seed value chain

The Grain Legume Research Program is the sole organization for breeder seed production. Seed companies, farmers' groups, the NSCL, cooperatives, NGO/INGOs and government organizations purchase breeder seed at NRs. 190/kg and foundation seed at NRs. 160/kg. Some of the registered seed companies and cooperatives also produce foundation seed following seed production standards developed by the Seed Quality Control Center (SQCC) and supply the seed-producing farmers at NRs. 160/kg for further multiplication. Seed companies add NRs. 8/kg to cover transportation and labor costs and provide foundation seed to farmers at a rate of NRs 168/kg. Cooperatives and farmer's groups provide foundation seed to the seed-producing farmers at a rate of NRs. 165, adding the NRs. 5/kg as a procurement cost. The Agriculture Knowledge Center, governmental organizations like municipalities and sub-metropolitan cities, NGOs and INGOs also provide foundation seed to the seed producing farmers either directly or through the cooperatives and farmers' group and serve as an input supplier.

The average price of lentil seed sold by the seed-producing contracted farmers was NRs. 85.58/kg, while the average cost of seed production was NRs. 53.72/kg, with a net profit of NRs. 31.8/kg. Seed-producing farmers sell their product to contracted agencies (mainly seed companies, cooperatives, farmers' group and the NSCL) for further processing. The average cost for collection and transportation was NRs. 4.4/kg for seed companies whereas it was NRs. 6.7/kg for cooperatives, NRs. 3.47/kg for farmers' groups and NRs. 5/kg for the NSCL. For seed companies, the total cost of purchasing seed from the seed-producing groups was NRs. 89.98/kg, the total collection and processing cost was NRs. 23.93/kg and the selling rate was NRs. 146.33/kg, with a net profit of NRs. 32.42/kg. Likewise, for cooperatives, the total collection and processing cost was NRs. 27/kg and the selling price for agrovets was NRs. 141.28/kg, with a net profit of NRs. 22/kg. For farmers' groups, the total cost of seed collection and processing was NRs. 112.98/kg, while the selling price from agrovets was NRs. 138.6/kg, with a net profit of NRs. 25.62/kg. Due to the lack of seed-grading machines in the NSCL, grading was carried out manually with traditional *chalno*, resulting in a higher processing cost. For the NSCL, the total collection and processing cost was NRs. 119.65/kg, while the selling price to agrovets was NRs. 146.4/kg, with a net profit of NRs. 26.75/kg. Cooperatives and farmers' groups also directly sold processed seed to improved seed users at rates of NRs. 155/kg and NRs. 153/kg respectively. For agrovets, the total cost of transportation and handling was NRs. 4.73/kg. However, the average selling rate was NRs. 161.26/kg. For seed companies, cooperatives, farmers' groups and the NSCL, Agrovet is the major retailer for improved seed sales. On average, the net profit for retailers was NRs. 10.16/kg but the profit per unit was higher when purchasing through farmer's groups.

Cost and margin analysis of the lentil seed value chain

The total cost involved in seed production by the farmers was NRs. 53.72, which is 61.87% of the total cost of the value stream. The total cost for the seed producer included production, cleaning, storage, packaging and local transportation up to the point of delivery. The total margin for the seed producer was found to be NRs. 31.8/kg, which is 45.8% of the total profit in the chain.

Lentil seed producers sold their product at a rate of NRs. 85.58/kg to the contracted agencies. Then, seed collectors and processors performed various activities to add value. Major costs involved in value addition activities were grading, packaging, processing and fungicidal treatment. The total cost of value addition was NRs. 28.38, which is 32.68% of the total value addition cost. However, such value adding actors receive a higher profit of NRs. 27.35/kg, which is 39.4% of the total profit in the chain. The average price of seed selling after value addition was NRs. 141.31/kg. Agrovets were the major retailer of value-added lentil seeds. The total cost involved in lentil seed production, collection, processing and retailing was NRs. 86.83/kg, which is

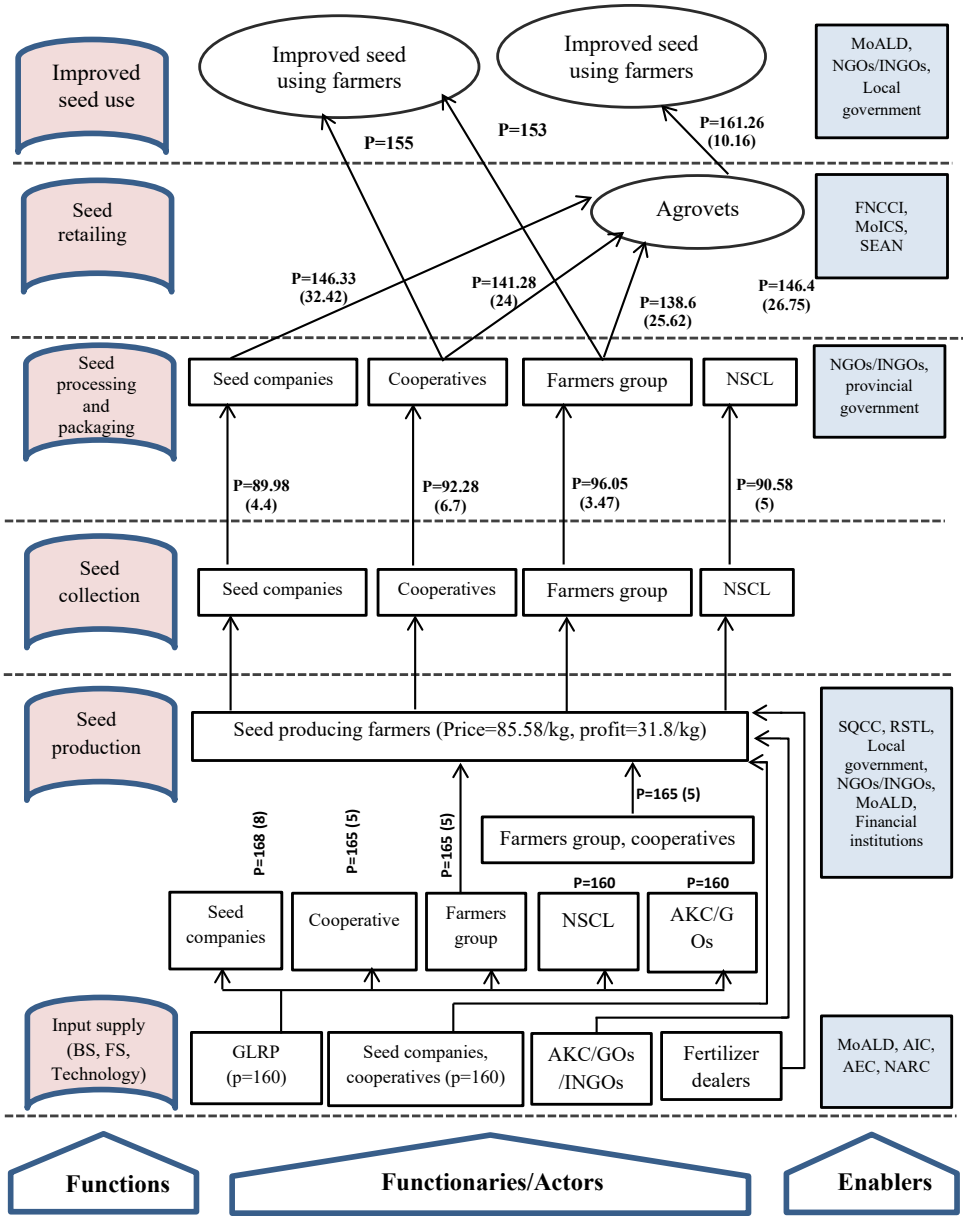

Fig. 2. Flow of price and value in the value chain of lentil seed subsector
Source: field survey, FGD & KII, 2021.

55.58% of the average retail price, while the total profit in all chains and for all actors was NRs. 69.37/kg, which is 44.42% of the average retail price. The total price paid by the improved seed users was NRs. 156.2/kg and the total price received by the seed-producing farmers was NRs. 85.58/kg, signifying a total price spread of 45.21% of the total consumer's price.

Value addition and net margin for actors involved in the lentil seed value chain

The value added from farm gate to end-user farmer level for the selected value chain in the surveyed region was 55.58% of the total retail price. The largest value addition of 61.87% was at the farmer level. The second largest value addition of 32.68% was at the collector and

Table 4. Cost and margin analysis of lentil seed value chain in the study area

Value stream	Cost involved	Cost (NRs./kg)	Margin (NRs./kg)	Selling Rate (NRs./kg)
Seed producer	Production, cleaning, storage and packaging, local transportation up to point of delivery	53.72 (61.87)	31.8 (45.8)	85.58
Seed collector and processor (Cooperative/ Farmers group/NSCL/Seed company)	Collection, storage, processing loss, packaging, processing, treating, drying and handling	28.38 (32.68)	27.35 (39.4)	141.31
Retailers/Agrovets	Transportation, handling, losses, storage, communication and taxes	4.73 (5.44)	10.16 (14.8)	156.2
Total		86.83 (55.6)	69.37 (44.4)	156.2
Price spread (%)				45.21

Figures in parentheses indicate percentages. The price spread is expressed as a percentage of consumer price-producer price/consumer price.
Source: field survey, FGD & KII, 2021.

processor level, followed by 5.4% at the retailer level. The 55.58% of value addition and its rational distribution among actors shows the better performance of the lentil seed value chain. In addition to value addition, there was employment generation and use of local materials at the local level. The ROI was 59.3% for farmers, 24% of the total cost and 96.3% of the added cost for the collector and processor and 214.8% of the added cost for retailers. The total ROI for the overall lentil seed value chain was 47.5% of the total cost and 79.89% of the value added cost.

Lentil seed value chain analysis

Study and analysis of the lentil seed value chain has shown that it operates in a competitive market but found unmanaged, weak backward and forward linkages between the actors. The integration of informal and formal seed systems creates complexity in a clear process and linkages. A similar result was found in the study by Mishra, Joshi and Dutta (2018). The GLRP is the sole government agency responsible for breeder seed production and distribution. For foundation seed production, NARC stations are the major stakeholders, followed by private seed companies and cooperatives. Research on seed sector development conducted by public institutions has found it to be weak and not competitive, as reflected by the limited varieties available in the market and poor competition in the regional and international markets. Many successful seed companies still depend on public universities or research institutes

Table 5. Value addition and net margin for actors involved in the lentil seed value chain

Actors	Costs			Revenues	Profits		Margins		ROI (%)	
	total cost (NRs./kg)	added cost (NRs./kg)	added cost (%)	price (NRs./kg)	profit (NRs./kg)	profit (%)	gross margin (NRs./kg)	retail price (%)	total cost	added cost
Seed producing farmers	53.72		60.49	85.58	31.86	45.92	85.58	58.78	59.3	59.3
Collector and processors	113.96	28.38	32.68	141.31	27.35	39.42	55.73	35.67	24	96.37
Retailers	146.04	4.73	5.44	156.2	10.16	14.64	14.89	9.53	6.95	214.8
Total		86.83	100		69.37				47.5	79.89

Source: field survey, FGD & KII, 2021.

to get germplasm and sometimes source seed (Tripp et al., 2007). The NSCL is the public organization for the supply of improved seed for many crops, including lentils, through a value chain approach. However, cereals rather than lentils have been its main focus, so that lentils have suffered from an inconsistent, poor and less competitive working model. Seed companies, cooperatives, farmers' groups and the NSCL are the dominant actors in the Nepalese seed system, but the programs of public institution like the NSCL are dominant in major cereal crops and performing in a less competitive model (Joshi et al., 2012). Agrovets are the major stakeholder for the retailing of improved lentil seed. About 65% of the total improved seed produced by the GATE Nepal seed company was marketed by agrovets in the Banke and Bardia district of Nepal (Sen, 2013). However, there exist higher profit margins for such retailers.

The adoption of different varieties of improved seeds creating demand for value-added product was the major pulling force for the overall lentil seed value chain. Mainly because of biotic and abiotic stresses in recent years and the dominance of the informal seed system, farmers' demand for improved seed decreased dramatically. Poor performance of improved varieties in farmers' fields, the persistence of stresses and the lack of availability of resilient varieties resulted in heavy yield losses. A study conducted by CSISA (2018) reported that large plot demonstrations of new and pipeline varieties under best management practices were implemented by four seed companies and this initiative helped to speed up the dissemination of high-performing varieties at scale. This increased the demand for improved seed, influencing the whole seed value chain. Without the intervention of a suitable seed distribution and adoption program, it is very difficult to raise the demand for improved seed from the farmer's side. Previously, improved lentil seed was distributed by the government organization (especially DADOs) with seed purchase subsidies, but currently, due to the federal transformation, there is almost no such program, hence the demand for improved seed is very low and seed-producing organizations are unable to sell lentil seed and instead dispose of it as grain at a low price. One study revealed that there is a non-significant difference between the yield from local lentil seed and the yield from improved seed. Practices in lentil cultivation should be delivered to increase the demand for improved seed. Higher value addition was achieved by seed-producing farmers followed by processors and retailers, but ROI was higher for retailers followed by processors and seed producers. There were higher price spreads in the lentil seed value chain, signifying a higher gap between the price paid by the improved seed user and the price received by the seed-producing farmers. This result was similar to that of the study of Mishra et al. (2018), in which an analysis of the maize seed value chain has shown higher cost involvement but lower profit was taken by seed producing farmers, ensuring a higher price spread. The analysis of knowledge, technology and information flow showed areas being upgraded by quality control agencies to enforce rules, regulations and directives. Seed producers need to train on quality control and marketing aspects. Seed collectors and processor need to be empowered through quality control and capacity building to handle seed consignment without compromising the quality.

Problems with lentil seed/grain production and marketing

A lack of technical/scientific cultivation knowledge was the major problem, with the highest index value of 0.756. Most of the farmers did not have scientific lentil cultivation knowledge. They use their traditional farming experience, and a significantly lower number of farmers are adopting scientific cultivation techniques. Similarly, farmers had faced serious problems with pests/disease in the study area, which ranked as the second most serious problem, with an index value of 0.755. *Stemphylium blight* and root rot were the major diseases in the study area while lentil aphid was the major pest. Heavy rainfall just prior to flowering and at flowering was also found to be a serious problem in attaining a desirable yield of lentils. Lentil-producing farmers can realize up to a 100% yield loss, mainly due to erratic heavy rainfall at the time of flowering and incidence of *stemphylium blight* disease. Lentil *Stemphylium blight* disease, caused by *Stemphylium botryosum,* once had a less significant effect, but now it is a serious threat to lentil cultivation in many parts of the world (Das et.al, 2019). Research conducted in different regions showed that yield loss due to *Stemphylium blight* is up to 100% depending on disease severity (CSISA, 2018). Studies conducted by Sarker (2011), Kumar et al. (2013), Sharma and Joshi (2021) and Shrestha et al. (2011) have also found that *Stemphylium blight* is a major disease of lentils which can cause yield losses of up to 100%. A similar study conducted by Thapa Magar, Gauchan and Darai (2014)

also revealed that limited availability of quality seed of improved varieties, limited awareness of farmers about improved lentil varieties and production technologies, uncertain rainfall leading to heavy disease infestation, and the occurrence of early and terminal droughts during lentil growing are threatening to undermine sustainable lentil production in Nepal. Among various marketing-related problems, the values obtained from the ranking scale revealed that price fluctuation—mainly as a result of the lack of a scientific pricing mechanism—is the major trade problem, with an index value of 0.783. Farmers are getting a low farm gate price in comparison with the retail price. This higher gap between the farm gate price and the retail price was the second most important marketing problem, with an index value of 0.746.

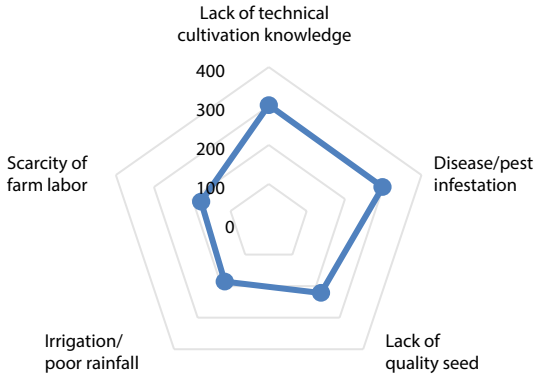

Fig. 3. Problems with lentil grain/seed production
Source: field survey, 2021.

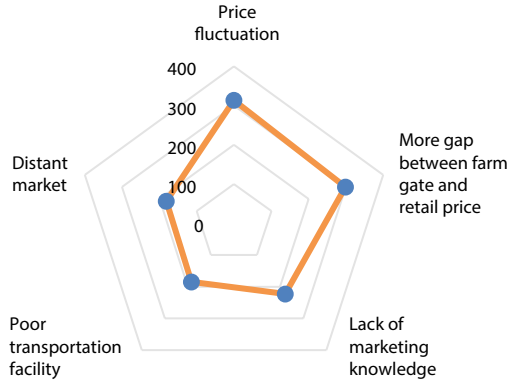

Fig. 4. Problems with lentil seed/grain marketing
Source: field survey, 2021.

Major reasons contributing to the low lentil seed replacement rate

Many socio-economic and geographical factors have affected the adoption of improved lentil seed by farmers. An analysis of the economics of lentil seed and grain production reveals that there is a statistically non-significant difference in yield, income and benefit-cost ratio when using improved lentil seed rather than local seed. The B:C ratio was 1.5 for improved seed users while it was 1.38 for local seed users. However, comparing the price of improved seed and local seed, there was a significantly higher price for improved seed. Price discrimination from agrovets was persistent and some lentil grain-producing farmers are paying up to NRs. 220/kg for improved lentil seed. However, the price of local seed was only up to NRs. 110/kg. The price of improved seed was almost double, but the return was the same compared with local seed, so why should farmers adopt improved seed? This is the most important issue to discuss while formulating any policies and programs related to the lentil seed system. A study conducted by Khojne, Manda, Alene and Kassie (2015) on the adoption of improved varieties of maize in Zambia strongly supports this finding about the relationship between improved varieties and income. The authors argue that higher adoption of improved varieties of maize is strongly related to the receipt of a higher income from improved varieties than local varieties.

This study also found that only 44.67% of local seed users have knowledge about the importance of using improved lentil seed, and very few of them are replacing local seed with improved seed annually. The majority of lentil producers do not even have any knowledge about the importance of using improved seed. The diffusion of knowledge about new technologies and innovations through an effective extension approach to smallholder farmers is one of the most important factors for higher adoption of those technologies and innovations (Mwangi and Kariuki, 2015). Higher yield loss from erratic rainfall during the reproductive stage and the incidence of disease has also prevented farmers from using improved seed. The majority of the lentil grain and seed producers follow traditional methods of lentil cultivation. Incentive schemes to improve lentil seed purchases were almost absent in many local administrative bodies within the study area and only a few were planned for the upcoming years. All these factors were found to directly affect improved seed use by lentil producing

farmers, resulting in very low lentil seed replacement rates in Nepal.

At present, the formal seed system of Nepal is dominated by major cereals (rice, wheat and maize) in market-accessible areas, where formal sector agencies are focusing their seed production, supply and quality regulation. The development of the seed industry is largely restricted to minor crops and distant (hilly and mountainous), regions where farmers continue to reuse low-yielding, locally produced, subpar seeds. This study found that lentils account for only 2.15% of total improved seed produced while rice accounts for almost 49.16% and wheat almost 37.83%. Similarly, the production of foundation lentil seed accounts for only 3.97% while rice accounts for 48.28% and wheat 45.54%. This result was similar to that of Sah (2014), who found that during 2011/12, out of total breeder seed produced by NARC, lentil seed accounted for 1% while rice accounted for almost 33% and wheat almost 55%. In the same year, out of the total foundation seed produced, lentil seed accounted for only 1.37% while rice and wheat accounted for 51.54 and 27.41% respectively. Similarly, out of the total improved seed produced by many organizations, lentil seed accounted for only 1.26% while rice and wheat accounted for 38.12% and 50.26% respectively.

Present variety development, source seed production and quality assurance services are dominated by public sector agencies. Private sector participation in varietal development, maintenance and seed research is very limited. Despite the dominance of public-sector agencies in agricultural research and development, there are critical gaps in human resource capacity and infrastructural facilities (Gauchan, 2017). Private seed companies are still low in seed system research and development and there exist constraints in public agricultural research organization and agricultural extension systems. Limited varieties dominate the formal seed market of major food crops, including lentils, with a market flow of low varietal diversity and high varietal age. To date, GLRP has released/registered 14 varieties of lentil but almost 75% of the lentil grain/seed producing farmers have adopted only six varieties. This result is consistent with the study of Thapa Magar et al. (2014), in which the adoption of local varieties of lentils was found to be higher (43%), followed by Khajura Masuro-2 (31%) and Khajura Masuro-1 (16%), while other improved varieties had very low rates of adoption.

Possible interventions for improvement of the lentil seed system in the new federal system

Capacity building of lentil seed value chain actors, the introduction of a package of practices for lentil grain/seed producing farmers, training and technical assistance, and development of stress resilient lentil varieties can all be part of the potential strategy for strengthening the lentil seed sector of Nepal. Some of the public and private sector actors are providing knowledge on new technologies, including diverse varieties of improved seed, through the pathways of Farmers Acceptance Trials (FAT), Informal Research and Development (IRD), demonstration trials, field visits, and extension visits (Gauchan, 2017). Capacity building of seed-producing farmers helps to maintain the quality of the source seed; capacity building of processors and entrepreneurs helps quality assurance as well as increasing involvement in research and development, with a timely supply of seed at an appropriate price margin. Training focused on seed dealers and retailers is also essential as they provide advisory services on crop production to farmers. Training, field visits, extension visits, on-farm research and involvement of cooperatives and farmer systems can increase the knowledge levels of seed-producing and seed-consuming farmers, ultimately benefiting the national seed system (Sisay et al., 2017).

The local seed system, which still dominates nearly 90% of seed requirements in Nepal, is under severe stress from climate change, youth outmigration and a lack of commercialization. In order to satisfy the seed demands of various crops, a resilient integrated seed system that integrates both formal and informal seed systems is required. In fact, analysis of the strengths and weaknesses of both the farmer and formal seed system shows important complementarity in strength and weaknesses between the two systems, which offers multiple opportunities to improve the effectiveness of both (Almekinders and Louwaars, 2002). Since the majority of the seed is supplied through the informal seed system, strengthening the local seed system through a community-based approach is critical for enhancing access to seeds of locally adapted varieties among farming communities. Community-based seed production and distribution programs, community seed banks and community-based seed infrastructure in rural marginal production systems are potential strategies for strengthening the local seed system. Such innovations also have the potential to pool

resources in the face of climate calamities through the sharing of accessions among community seed banks at the regional or national level as well as between community seed banks and national and international gene banks (Shrestha et al., 2013).

In the present context, the creation of an enabling environment with better provision of incentive systems is required to attract and incentivize private seed companies, cooperatives, plant breeders and agribusiness firms in order to strengthen the formal lentil seed system. Incentives for seed producing farmers based on production, performance and governance for cooperatives, seed-producing farmers, seed-producing farmers' groups, private seed companies and agrovets should be provided to encourage lentil seed production and quality control mechanisms. The government is investing a large amount of money to provide incentives in fertilizer, but no such incentive scheme can be seen in the seed sector. A study conducted by Bista et al. (2016) found that subsidy schemes help to lower the cost of production, especially for marginal farmers. There is an urgent need to implement strong seed incentives for related stakeholders to strengthen the lentil seed system of Nepal. The resulting national seed industry should be a viable and sustainable business which enhances agricultural growth to positively impact the national economy with the participation of the private, community, cooperative, non-governmental and public sectors.

Strengthening quality assurance services is another point of intervention for the improvement of the lentil seed system in the new federal system. This study found that the recently introduced seed regulatory framework assigned for flexible quality assurance services is supporting and encouraging growth of seed enterprises in the community and in the private sector. But there is an increasing flow of seeds of unregistered varieties and seeds lacking formulated quality standards, and there is a major problem in the pricing mechanism in the market, which requires strong quality and market monitoring mechanisms. A similar argument was also presented by Kandel et al. (2014), who concluded that it was necessary to improve the present situation of seed quality through proper field inspections, seed testing and certification systems.

CONCLUSION

Despite higher trade potential, the increasing consumer demand and decreasing production of lentils has led to a ballooning trade deficit in Nepal. Increased production and yield of this sector through structural transformation and innovation can stabilize this unacceptable situation. The adoption of higher quality improved lentil seed not only increases production but also escalates the efficiency of other inputs and is the most viable option to cope with this situation. An inclusive, competitive and sustainable lentil seed system can be established through a value chain approach. Stunted demand for improved seed from lentil producing farmers has engendered a distorted lentil seed value chain and overall seed system in Nepal. Scaling up the major factors of improved seed adoption activities, like specialized production areas, the development of stress-resistant varieties, technical assistance, training, subsidy schemes based on production and efficient market system development, can economically benefit lentil-producing farmers and ameliorate the major pulling force in the lentil seed value chain, thereby strengthening the seed system. The capacity-building activities of major value chain stakeholders, along with strengthening the public sector, which is responsible for technology development, is another intervention point. Value chains dominated by cooperatives and seed companies provide a higher-value product to the consumer. However, the profit margin should be adjusted by these vital chain actors in accordance with the added cost to the seed companies and retailers. Price monitoring for retailers needs to be reinforced for price regulation. The working modality of the NSCL, which has dominated the public sector value chain, should be reformed with the inclusion of value addition technology and proper governance. The higher price spread in the lentil seed value chain, signifying a higher gap between the price paid by the improved seed user and the price received by the seed producing farmers, should be brought down through an efficient marketing system, a scientific pricing mechanism and a market support program. Government prioritization along with intensive coordination and communication between the three tiers of government with respect to lentil seed system policy issues is urgently needed to create an inclusive, competitive and sustainable lentil seed system in Nepal.

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REFERENCES

Abebe, G., Alemu, A. (2017). Role of improved seeds towards improving livelihood and food security at Ethiopia. Int. J. Res.-Granthaalayah, 5(2), 338–356. DOI: http://dx.doi.org/10.29121/granthaalayah.v5.i2.2017.1746

Almekinders, J.M.C., Louwaars, N.P. (2002). The Importance of the Farmers' Seed Systems in a Functional National Seed Sector. J. New Seeds, 4(1–2), 177–193. DOI: https://doi.org/10.1300/J153v04n01

ANSAB (2011). Value Chain / Market Analysis of the Lentil Sub-Sector in. In: USAID (Issue August).

Bélanger, G., Thijssen, M., Gildemacher, P., Subedi, A., De Boef, W.S., Heemskerk, W. (2013). Seed Value Chain Analysis (Issue 3).

Bista, D.R., Dhungel, S., Adhikari, S. (2016). Status of fertilizer and seed subsidy in Nepal: review and recommendation. J. Agric. Env., 17, 1–10. DOI: https://doi.org/10.3126/aej.v17i0.19854

Collins, R. (2009). Value chain management and postharvest handling: partners in competitiveness. In: W.J. Florkowski, R.L. Shewfelt, B. Brueckner, S.E. Prussia (Eds.), Postharvest Handling: A Systems Approach. Elsevier.

CSISA (2018). Agronomy & Seed Systems Scaling (Issue April). Semi-annual report April 2018. Pp 1-28.

Erskine, W., Muehlbauer, J.F., Sarkar, A., Sharma, B. (2009). The Lentil: Botany, Production and Uses. In: B. Erskine, W. Muehlbauer, J.F., Sarkar, A., Sharma (Ed.), The lentil: Botany, Production and Uses (pp. 1–4). CABI International.

FAOSTAT (2022, May 17). Statistics division, Food and Agriculture Organization of the United Nations. http://www.fao.org/faostat/en/#data

Faris, M.A.I.E., Takruri, H.R., Issa, A.Y. (2013). Role of lentils (*Lens culinaris* L.) in human health and nutrition: A review. Mediterr. J. Nutr. Metab., 6(1), 3–16. DOI: https://doi.org/10.1007/s12349-012-0109-8

Gauchan, D. (2019). Seed sector development in Nepal: Opportunities and options for improvement. In: A.K. and P.K.J. Ganesh Thapa (Eds.), Agricultural Transformation in Nepal (pp. 199–208). Springer. DOI: https://doi.org/10.1007/978-981-32-9648-0_17.

ITC (2019, November 17). Trade Help Desk. International Trade Center (ITC). https://globaltradehelpdesk.org/en/export-071340-from-ca-to-np/explore-markets

Joshi, K.D., Conroy, C., Witcombe, J.R. (2012). Agriculture, seed, and innovation in Nepal: Industry and policy issues for the future. Int. Food Polic. Res. Inst., 1–60.

Kandel, M., Pandey, S., Padhyoti, Y., Adhikari, S., Shrestha, P. (2014). Approaches and Strategies of Quality Seed Production and Control Mechanism in Nepal (No. 1; 1, Issue September). DOI: https://doi.org/10.13140/RG.2.2.17450.72640.

Khonje, M., Manda, J., Alene, A.D., Kassie, M. (2015). Analysis of adoption and impacts of improved maize varieties in eastern Zambia. World Dev., 66, 695–706.

Kim, S.J., De Souza, R.J., Choo, V.L., Ha, V., Cozma, A.I., Chiavaroli, L., Mirrahimi, A., Blanco, M.S., Di Buono, M., Bernstein, A.M., Leiter, L.A., Kris-Etherton, P.M., Vuksam, V., Beyene, J., Kendall, C.W.C., Jenkins, D.A., Sievenpiper, J.L. (2016). Effects of dietary pulse consumption on body weight: a systematic review and meta-analysis of randomized controlled trials. Am. J. Clin. Nutr., 103(5), 1213–1223. DOI: https://doi.org/10.3945/ajcn.115.124677

KUBK (2017). Seed Replacement Rate (SRR) Study of Cereal and Vegetable in Program Districts. In: Seed Replacement Rate (SRR) Study of Cereal and Vegetable in Program Districts (vol. 14, iss. 2).

Kumar, A., Roy, D., Joshi, P.K., Tripathi, G., Adhikari, R.P. (2016). Impact of contract farming on profits and yield of smallholder farms in Nepal: An evidence from lentil cultivation.

Kumar, S., Bourai, V.A. (2012). Economic Analysis of Pulses Production Their Benefits and Constraints (A Case Study Of Sample Villages Of Assan Valley Of Uttarakhand, India). IOSR J. Human. Soc. Sci., 1(4), 41–53. DOI: https://doi.org/10.9790/0837-0144153.

Kumar, S., Barpete, S., Kumar, J., Gupta, P., Sarker, A. (2013). Global lentil production: constraints and strategies. SATSA Mukhapatra-Ann. Tech., 17, 1–13.

Mishra, R.P., Joshi, G.R., Dutta, J.P. (2018). Integrating structure conduct and performance framework for maize seed value chain analysis in western Nepal. Eur. Acad. Res., 5(12), 6527–6562.

Mishra, R.P., Joshi, G.R., KC, D. (2017). Adoption of Improved Variety Maize Seed Production Among Rural Farm Households of Western Nepal. Int. J. Agric. Inn. Res. 6(2), 2319–1473.

MoALD (2020). Statistical information on Nepalese agriculture 2075/76 (2018-19). Government of Nepal, Ministry of Agriculture and Livestock Development, Statistics and analysis section. https://s3-ap-southeast-1.amazonaws.com/prod-gov-agriculture/server-assets/publication-1625998794412-f37e4.pdf

MoALD (2021). Statistical information on Nepalese agriculture 2076/77 (2019-20). Government of Nepal, Ministry of Agriculture and Livestock Development, Statistics and analysis section. https://s3-ap-southeast-1.amazonaws.com/prod-gov-agriculture/server-assets/publication-1625998794412-f37e4.pdf

MoALD (2022). Agriculture and Livestock diary 2079. Government of Nepal, Ministry of Agriculture and Livestock Development, Agriculture Information and Training Center, Kathmandu, Nepal. https://aitc.gov.np/downloadfile/agriculture%20diary%202079_1651480914.pdf

Mulugeta, F., Eshetu, J., Nikus, O. (2010). Seed Value Chain Analysis as a means for Sustainable Seed System: A case of farmers based seed production and marketing in Arsi Zone, Oromia Region. Asella (ET): FAO-Crop Diversification and Marketing Development Project.

Mwangi, M., Kariuki, S. (2015). Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. J. Econ. Sust. Dev., 6(5).

Panta, H.K. (2015). Impact of commercialization in rice seed production on crop productivity and household income. J. Inst. Agric. Anim. Sci., 11–18. DOI: https://doi.org/10.3126/jiaas.v33i0.20677

Sarker, A. (2011). Lentils in production and food systems in West Asia and Africa. Grain Legum., 57, 46–48.

Sen, A. (2013). Marketing GATE seeds to and through agrovets in Banke and Bardiya regions of Nepal. ARCADA

Shahwar, D., Bhat, T.M., Ansari, M.Y.K., Chaudhary, S., Aslam, R. (2017). Retracted Article: Health functional compounds of lentil (Lens culinaris Medik): A review. Int. J. Food Prop., 20(sup1), S1–S15. DOI: 10.1080/10942912.2017.1287192

Sharma, S., Joshi, L.P. (2021). Current Insights on Stemphylium Blight of Lentil with its Management Strategies. Sarhad J. Agric., 37(1), 247–261. DOI: http://dx.doi.org/10.17582/journal.sja/2021/37.1.247.261

Shrestha P., Vernooy, R., Chaudhary, P. (2013). Community Seed Banks in Nepal: Past, Present, Future. Proceedings of a National Workshop, LI-BIRD/USC Canada Asia/Oxfam/The Development Fund/IFAD/Bioversity International, 14-15 June 2012, Pokhara, Nepal.

Sisay, D.T., Verhees, F.J.H.M., van Trijp, H.C.M. (2017). Seed producer cooperatives in the Ethiopian seed sector and their role in seed supply improvement: A review. J. Crop Imp., 31(3), 323–355. DOI: https://doi.org/10.1080/15427528.2017.1303800.

Spielman, D.J., Kennedy, A. (2016). Towards better metrics and policymaking for seed system development: Insights from Asia's seed industry. Agric. Syst., 147, 111–122. DOI: https://doi.org/10.1016/j.agsy.2016.05.015.

SQCC (2017). Proceedings National Seed Summit, September 14–15, 2015, Kathmandu. Seed Quality Control Centre (SQCC), Ministry of Agricultural Development, Government of Nepal, Kathmandu.

SQCC (2019). National Seed Balance Sheet 2076-77 (3rd ed.). Seed Quality Control Center (SQCC), Ministry of Agriculture and Livestock Development (MoALD), Kathmandu. https://www.sqcc.gov.np/pages/seed-balance-sheet-2078-79

Sultana, T., Ghafoor, A. (2008). Genetic diversity in ex-situ conserved Lens culinaris for botanical descriptors, biochemical and molecular markers and identification of landraces from indigenous genetic resources of Pakistan. J. Integr. Plant Biol., 50(4), 484–490. DOI: 10.1111/j.1744-7909.2007.00632.x

Thapa Magar, D.B., Gauchan, D., Darai, R. (2014). Varietal Adoption and Marketing of Lentilin the Mid and Far Western Terairegion of Nepal. Adv. Plants Agric. Res., 1(5), 1–6. DOI: https://doi.org/10.15406/apar.2014.01.00026

Thapa, G., Kumar, A., Joshi, P. (2019). Agricultural transformation in Nepal. Trends, Prospects, and Policy Options. DOI : https://doi.org/10.1007/978-981-32-9648-0

Tithi, S.M., Barmon, B.K. (2018). Comparative advantages of lentil (*Lens culinaris*) and mustard (*Brassica nigra* L.) Production and their Profitability in a Selected District of Bangladesh. Agriculturists, 16(1), 21–33. DOI: https://doi.org/10.3329/agric.v16i1.37531

Tripp, R., Louwaars, N., Eaton, D. (2007). Plant variety protection in developing countries.A report from the field. Food Policy, 32(3), 354–371. DOI: https://doi.org/10.1016/j.foodpol.2006.09.003

Wimalasekera, R. (2015). Role of seed quality in improving crop yields. In: Crop production and global environmental issues (pp. 153–168). Springer, Cham. DOI: 10.1007/978-3-319-23162-4_6