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Research Article

Tradition of Cultivating Bean Mixture for Multiple Benefits and Sustainable Production System in Mountain Agriculture

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Abstract

Bean mixture cultivation is a traditional practice in mountain agriculture, though it has been increasingly replaced by monoculture. This survey explored the ecological, cultural, and economic factors driving the widespread adoption of bean mixtures in the Karnali region of Nepal. A household survey consisting of 42 questions was conducted among 34 households in Humla and 40 households in Jumla district. On average, households in Jumla cultivated beans on 1.93 *ropani* of land, while in Humla, the average area was slightly larger at 2.4 *ropani* (1 ropani = 0.05 a). In Jumla, 55% of respondents reported cultivating bean mixtures, compared to only 30% in Humla. Jumla farmers cultivated 30 distinct landraces of beans, while Humla farmers grew 12 landraces. In Jumla, 44% of farmers grew mixtures of four landraces, and 5% grew as many as seven landraces. In Humla, 32% of farmers mixed five landraces, 23% mixed three or four, and 11% mixed six landraces. The most commonly grown landraces in Jumla were Kalo Male, Sano Kalo, Rato Male, Rato Sano, and Kalo Sano. In Humla, Kalo Male, Seto Male, and Kalo were the most frequently grown landraces. Most respondents noted that mixed beans have a good taste and reduce the risk of crop failure. Enhancing and promoting bean mixture technology could benefit farmers by increasing ecological yield and supporting agroecological practices.

Keywords: Bean mixture, Landrace, Disease, Insect pest

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Introduction

Beans are a vital pulse crop in Western Nepal, particularly in the districts of Jumla and Humla (Bhujel, 2014, Prasad et al., 2016, Palikhey et al., 2016). The practice of cultivating mixed landraces of beans has been passed down through generations in these regions maintaining a rich diversity of bean varieties (Parajuli et al., 2016, Joshi et al., 2020b). This unique practice not only preserves crop diversity but also provides effective solutions for managing biotic and abiotic stresses (Ssekandi et al., 2016, Bhujel et al., 2014). The growing bean mixtures helps farmers cope with threats such as disease outbreaks, pest infestations (Castro, 2001, Finckh et al., 2000, Koizumi, 2001, Mundt, 2002, Zhu et al., 2000, Joshi et al., 2020b, Ssekandi et al., 2016) and poor soil conditions.

A wide range of variations in traits such as seed coat color, shape, plant type, leaf size, pod characteristics, and root structure has been observed in the Jumli bean collections (Neupane et al., 2007, Vista et al 2020, Bhujel et al., 2014, Palikhey et al 2016, Parajuli et al., 2016). These local mixtures serve as a valuable gene pool for the development of pure-line varieties (Neupane et al., 2007; Bhujel et al., 2014).

This survey aimed to provide deeper insights into the ecological, cultural, and economic factors driving bean mixture cultivation in Karnali. This study has explored the reasons behind the widespread adoption of bean mixtures and why this method was less common for other crops.

Methodology

Two villages in each of Jumla and Humla districts were selected based on the predominance of bean mixture cultivation. These sites were identified through key informant surveys including input from officials from District Agriculture Development Offices and traders. In Humla, Sarkideu and Chhipra were chosen, while in Jumla, Hanku and Depalgau were selected, representing diverse production systems, ecological zones, and the dominance of bean mixtures (Figure 1). The selection process considered the entire district, and the detailed methodology is outlined in Figure 2.

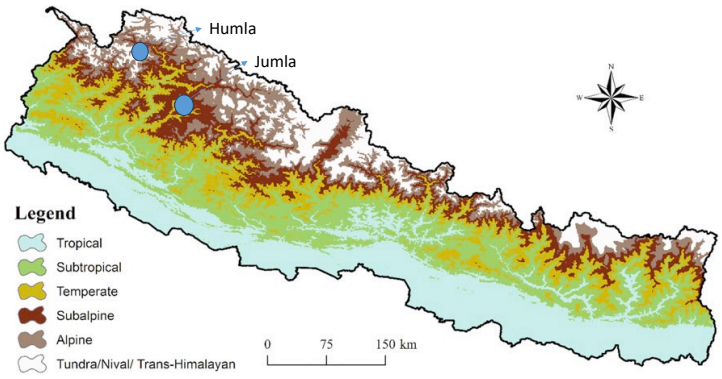

Fig. 1. Survey sites (Humla and Jumla districts)

Source of Map: Paudel et al., 2021

The survey was conducted using 42 structured questionnaires developed based on findings from a focus group discussion (FGD) and key informant surveys (KIS) published in Joshi et al. (2020b). The study explored several themes, including the reasons behind cultivating beans in mixtures. It aimed to understand if modern farmers were aware of the rationale behind this method, which includes risk management (pests, disease, climate uncertainty, poor soil conditions) (Joshi et al., 2020b, Koizumi, 2001, Mundt, 2002) and the reduction of labor, especially for women.

The household survey sample size included 34 households in Humla (11 male and 23 female respondents) and 40 in Jumla (19 male and 21 female respondents). These households were chosen from areas where bean mixture cultivation is predominant, ensuring diverse representation across different production systems.

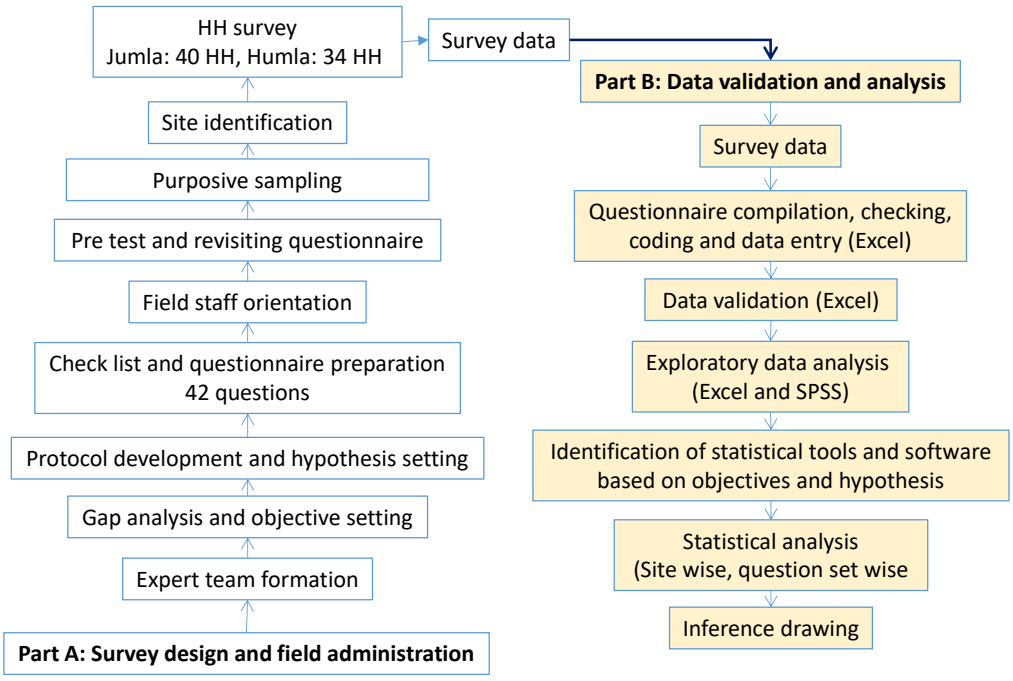

Fig. 2. Steps for bean survey in Jumla and Humla districts, and data analysis used in this study, HH: Household.

Field staff received training prior to administering the questionnaire in the field. After data collection, the project team worked closely with the field staff to validate the data by reviewing each question and conducting exploratory analysis. The responses were coded and entered into MS Excel for further analysis, where frequencies and percentages were calculated.

Findings and Discussion

Regarding gender distribution, there were 21 female respondents in Jumla and 23 in Humla, highlighting women's significant role in farming activities in both districts (Table 1). The average family size was slightly larger in Jumla, with 6.15 members per household, compared to 5.9 members in Humla. On average, households in Jumla cultivated beans on 1.93 *ropani* (1 *ropani* = 0.05 ha) of land, while in Humla, the average area was slightly larger at 2.4 *ropani*.

Table 1. Respondent details and their land areas

SN	Particular	Jumla	Humla
1.	Total respondent, n	40	34

2.	Male and female, n	19 and 21	11 and 23
3.	Family size (Min-Max), n	6.15 (3-13)	5.9 (3-11)
4.	Total cultivated area, (Min-Max), *ropani*	4.8 (1.5-15)	10.5 (1.06-30)
5.	Area under bean, (Min-Max), *ropani*	1.93 (0.5-4.5)	2.4 (0.5-10)

One *ropani* = 0.05 ha

Bean Mixture and Their Characters

In Jumla, 55% of respondents reported growing bean mixtures, while only 30% did so in Humla (Figure 3). Additionally, 40% of Jumla farmers cultivated sole and mixed beans, a practice not observed in Humla. The names of the various landraces are generally based on seed color, size, and shape, such as *Kalo Sano Dalle*, where the first part refers to color, the second to shape, and the third to size.

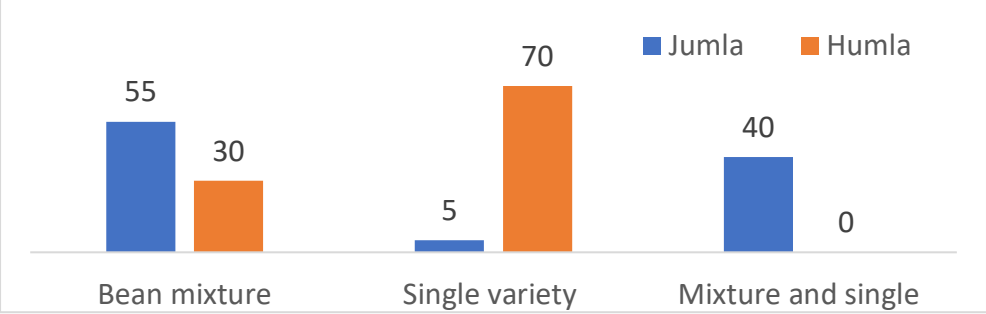

Fig. 3. Percentage of mixture and single varieties growers

Farmers in both districts have maintained and cultivated different numbers of landraces per household. In Jumla, 52% of single landrace growers cultivated only one type of bean, while 18% grew up to three landraces and 11% grew up to four landraces. Similarly, in Humla, single landrace growers maintained between one and seven types of beans per household, with 10% growing two landraces, 25% growing up to four landraces, and 4% growing as many as seven landraces separately. The number of landraces in mixtures also varied. In Jumla, 44% of farmers grew mixtures of four landraces, 15% grew five, 17% grew three, and 5% grew as many as seven landraces. In Humla, 32% of farmers mixed five landraces, 23% mixed three or four, 11% mixed six, and 6% mixed two.

The most commonly grown landraces in Jumla were *Kalo Male* (34.2%), *Sano Kalo* (13%), *Rato Male* (10.5%), *Rato Sano* (10.5%), and *Kalo Sano* (10.5%). Less common varieties included *Rajma Bean* (5%), *Pahenlo Besare* (2.6%), and *Kalo Lamo* (2.6%). The main reasons for cultivating these varieties included consumer

preference (*Rato Male*), easy marketing (*Rato Sano*), high production (*Kalo Sano*), high market price (*Rajma Simi*), and taste (*Kalo Male, Kalo Sano, Kalo Lamo*). Some landraces were also chosen for their adaptability to less irrigated land (*Rato Sano*) or resistance to pests and diseases (*Pahenlo Besare*). In Humla, *Kalo Male* was the most commonly grown landrace, favored by 89% of farmers, followed by *Seto Male* (21%) and *Kalo* (7%). Less common varieties included *Kalo Dalle* (3.5%), *Seto* (3%), and *Seto Rato* (2%). Farmers in Humla primarily grew these landraces because of their taste and good performance in local conditions. Kalo Male Simi is a highly preferred landrace of bean known for its rich protein content (Joshi et al 2020a) and ability to fetch higher prices in the market.

Farmers in Jumla reported cultivating 30 distinct landraces of beans, while those in Humla grew 12 landraces. The specific characteristics of these landraces, along with the percentage of seed used in cultivation, are detailed in Table 2. In Jumla, *Rato Sano* was the most widely grown landrace, followed by *Kalo Sano*, *Kalo Male*, and *Rato Male*. In contrast, in Humla, *Kalo Male* was the most popular landrace, followed by *Seto*, *Kalo*, *Pahenlo*, and *Rato*.

In Jumla, the average percentage of landraces in a mixture was 9.88%, with a minimum of 0.80% and a maximum of 43%. In Humla, the average proportion was slightly higher at 11.22%, with a range from 0.5% to 40%. Farmers in both Jumla and Humla prioritized traits such as production, taste, and resistance to insect pests and diseases when selecting landraces for cultivation.

Table 2. Landraces and status in mixture and reasons of mixing

SN	Landrace	Jumla			Humla		
		Grower, n	Mixture (%)	Reason	Grower, n	Mixture (%)	Reason
1.	Besare	2	2.2	Higher production, Insect/pest/water stress tolerance			
2.	Ghiu Simi				1	4.5	Vegetable purpose
3.	Kaleji Chirke	2	9.4	Tasty			
4.	Kalo	7	6.7	Higher production, Tasty	24	18.4	Higher production, Early maturity, Tasty
5.	Kalo Chirbire	9	8.7	Early maturity, Tasty, High market price			
6.	Kalo Dalle				2	17.3	Early maturity
7.	Kalo Lamo	1	0.8	Compensate each other			
8.	Kalo Male	19	16	Higher production, High market price, Insect/pest/water stress tolerance, Non spreading type	32	40.1	Higher production, Early maturity, Tasty
9.	Kalo Rajma	3	19	Higher production, High market price			
10.	Kalo Sano	23	27	Higher production, Tasty, Compensate each other, Easy for intercultural operation			
11.	Kalo Thulo	1	2	Local variety			
12.	Khairo Dalle				1	8.3	Low production and taste
13.	Khairo Male	1	7.7	Higher production			
14.	Khairo Sano	2	7.3	Hardy			
15.	Pahenlo	1	2.1	Higher production	17	8.2	Early maturity, Not tasty
16.	Pahenlo Chiribire	1	3.4	Higher production	1	1	Tasty
17.	Rajma	2	13	Tasty, High market price			
18.	Rato	8	6.2	Tasty, Insect/pest/water stress tolerance,	15	5.3	Early maturity, Not tasty

SN	Landrace	Jumla			Humla		
		Grower, n	Mixture (%)	Reason	Grower, n	Mixture (%)	Reason
				Non spreading type			
19.	Rato Chiribire	2	7.9	Higher production, Tasty			
20.	Rato Dalle				1	0.5	Not tasty
21.	Rato Male	11	7.7	Higher production, Tasty, Compensate each other	2	3	Late maturity, Tasty
22.	Rato Sano	26	23	Higher production, Compensate each other, Insect/pest/water stress tolerance			
23.	Rato Seto Chiribire	2	5	Tasty			
24.	Rato Seto Sano	5	7	Higher production, Insect/pest/water stress tolerance			
25.	Rato Thulo	3	2.5	Medium type			
26.	Seto	3	5.4	Higher production, Insect/pest/water stress tolerance, Water lodging resistant	26	19.3	Higher production, Early maturity, Tasty
27.	Seto Lamo	2	3.8	Higher production, Early maturity			
28.	Seto Male	7	9	Higher production, High market price	17	8.7	Higher production, Tasty, Early maturity
29.	Seto Rajma	2	11	Higher production, High market price			
30.	Thulo Male	2	43	Compensate each other			

In Jumla, the practice of mixing multiple bean landraces is quite common, with variations in the number of landraces used. About 8% of respondents reported mixing five landraces, 31% mixed four, 34% mixed three, and 26% mixed two landraces. There are also a few farmers who mix six or seven landraces. A list of the landrace combinations is given in Table 3. In Humla, of those who cultivate mixed beans, 62% reported mixing four landraces, 12.5% mixed three, and 25% mixed two landraces. This diversity in the number of landraces highlights the farmers' strategy to enhance resilience and productivity through varietal mixtures. These different types could be the result of growing same mixtures over the generation and keeping seed from the same field. Advantages of mixtures have been explored by many researchers (Castro, 2001, Finckh et al., 2000, Mundt, 2002). Despite farmers maintaining their own seeds

for centuries, there have been no concerns regarding seed quality, making this traditional practice both sustainable and reliable. However, further research is needed to clarify potential naming inconsistencies, as there may be different names for the same landrace, or the same name could be assigned to distinct genotypes.

Table 3. List of landraces in bean mixtures

Jumla	Humla
Kalo Sano+Rato Sano	Kalo+Kalo Male
Male+Kalo Sano	Kalo Dalle+Pahelo
Kalo Male+Rato Sano	Kalo Male+Kalo Dalle+Seto Male
Rato Sano+Seto Thulo	Kalo Male+Kalo+Pahenlo+Seto
Kalo Male+Rato Male	Kalo+Kalo Male+Seto Male+Seto Dalle
Kalo Male+Rato Male+Seto Male	Kalo Male+Kalo+Rato Dalle+Seto Male
Seto+Kalo+Ghue Simi	Kalo Male+Kalo+Rato Dalle+Seto Male
Kalo Male+Kalo Sano+Rato Male	
Kalo Sano+Rato Sano+Seto Lamo	
Kalo Sano+Kalo Chiribire+Rato Sano	
Kalo Sano+Kalo Chiribire+Rato Lamcho	
Rato+Kalo+Kalo Chiribire+Rato Chiribire	
Kalo Sano+Kalo Thulo+Rato Sano+Rato Thulo	
Kalo Sano+Rato Sano+Seto Male+Kalo Male	
Rato+Kalo Sano+Rato Thulo+Seto Sano	
Kalo Sano+Rato Sano+Seto Thulo+Pahelno Thulo	
Kalo Male+Kalo Sano+Rato Sano+Rato Male	
Rato Male+Kalo Male+Rato Sano+Seto	
Kalo Male+Rato Male+Rato Sano+Kalo Sano	
Sano Rato+Rato Thulo+Kalo Chiribire+Rato Chiribire	
Kalo Male+Rato Male+Rato Sano+Kalo Sano	
Kalo Male+Kalo Thulo Male+Rato Sano+Rato Male	

Jumla	Humla
Kalo+Seto+Pahelo+Male	
Rato Sano+Seto+Kalo Male+Kalo	
Kalo Male+Kalo Sano+Rato Sano+Rato Male	
Seto+Kalo Sano+Kalo Chiribire+Rato Sano+Rato Chiribire	
Rato Sano+Besare Lamo+Kalo Male+Kaleji Chirke+Seto Chirke+Seto	

They identified specific landraces that posed challenges, and the common reasons for these concerns are detailed in Table 4. These drawbacks may include issues such as uneven maturation times, lower yields, or susceptibility to pests and diseases.

Table 4. Percent respondents on landraces that are not considered good in mixture

Landrace	Jumla, %	Reasons	Humla, %	Reason
Rato	12.5	Insect problem, difficult to sell, late maturity, less production, less/ not tasty, more black, less white, not tolerate to water lodging and small size grain	12	Insect problem, difficult to sell, late maturity, less production, less/ not tasty, more black, less white, not tolerate to water lodging and small size grain
Seto	5		18	
Rato Sano	55			
Kalo Sano	12.5			
Kalo				
Rato Male			3	
Pahenlo Chiribire			15	
Khairo Chirke	2.5		3	
Rato Dalle			3	

In both Jumla and Humla, the most preferred landrace to include in bean mixtures was *Kalo Male*. In Jumla, 45% of farmers reported favoring this landrace in their mixtures, while a significant 76% in Humla preferred it. In Jumla, other commonly preferred landraces for mixing were *Kalo Sano* (32.5%), *Kalo Chiribire* (10%), *Rato* (5%), and both *Kalo Lamo* and *Kalo Thulo* (each 2.5%). Additionally, 18% of respondents in Jumla indicated they did not want to mix landraces, while 16% preferred an improved variety, and 13% mentioned the *Seto Thulo* landrace. In Humla, farmers showed preference for *Kalo* and *Kalo Dalle* (each 6%), followed by *Rato*, *Kalo Thulo*, and *Seto Male* (each 3%). Furthermore, 6% of Humla farmers wanted to mix *Seto Sano*, *Kalo Dalle*, and *Chaumase* landraces.

Regarding whether their mixtures were similar to their neighbors', 69% of farmers in Jumla said their mixtures were the same, while in Humla, 18% reported having the

same mixtures as their neighbors, and another 18% indicated they used different combinations.

Crop Mixture

In addition to bean mixtures, farmers in both districts also practice crop mixtures, where different crops are grown together in the same field. In Jumla, 83.78% of respondents reported practicing crop mixtures, while in Humla, only 15.15% did, with 69.70% of Humla farmers not engaging in this practice. The reasons for mixing different crops vary and are presented in Table 5. While cultivar mixtures are widespread in bean cultivation, they are less common in other crops, especially in Jumla, due to differences in maturity times and lower yields. In Humla, 36% of farmers found it difficult to separate seeds in mixed cropping, and 3% mentioned challenges with crops not maturing simultaneously. Despite these challenges, crop mixtures remain an important traditional practice in the region.

Table 5. Crop mixture practices in Jumla and Humla districts

Crop mixture practice	Reason
Jumla	
Potato, Maize and Finger millet	Produce more than one crop, gives higher production, benefit each other from both crops
Proso millet, Potato and Maize	Higher production, produce even if one crop fail, mature early, make soil fertile, take two crops form the same land
Maize and Potato	Harvest 2 crops from same field
Finger millet and Potato	Increase production
Finger millet, Potato and Proso millet	Increase production
Potato and Proso millet	Production of more than one crops
Finger millet and Proso millet	Production of more than one crops
Finger millet, Proso millet and Soybean	Production of more than one crops, improve soil
Humla	
Proso millet, Finger millet, Potato, Foxtail millet	High production, less insect and disease, more than one crop from same land
Gram and Soybean	Improve soil, harvest two crops from same field
Seto potato and Rato potato	Harvest and conserve diversity of potato

History and Trend of Bean Mixture

The practice of cultivating bean mixtures has deep roots in both Jumla and Humla. In Jumla, 85% of respondents indicated that this tradition has been passed down from generation to generation, while 15% mentioned it started only a few years ago. Similarly, in Humla, 73% of farmers reported practicing bean mixtures for generations, with 20% noting that it began more recently.

Knowledge about bean mixture cultivation in Jumla is primarily inherited, with 73% of farmers learning it from their families, while others learned from neighbors. In Humla, however, only a small portion (7%) attributed their knowledge to generational learning, and 32% of respondents indicated that they did not practice bean mixtures at all. Over time, the trend of cultivating bean mixtures has been declining, with many farmers shifting towards monoculture, influenced by modern agricultural practices and promoting single high-yield varieties.

Reasons of Cultivating Bean Mixture

In Jumla, 69% of respondents cited tradition as the main reason for maintaining this practice, with an additional 15% emphasizing the taste of mixed beans. In contrast, 57% of farmers in Humla highlighted high production as the primary motivation for growing bean mixtures. These reasons vary across districts and households, reflecting different farming conditions and cultural practices. Other reasons for cultivating bean mixtures, as shown in Table 6, include ease of cultivation, reduced risk of crop failure, and good production even in poor soil.

Table 6. Percent respondents on reasons of growing bean mixtures

Reason	Jumla	Humla
High production and profitable	47	57
Early maturity	5	3
For consumption	12.5	
Less chance of whole crop loss due to insect/pest	15	18
Compensation in production from each other	5	18
Time saving and easy production practice	20	10
Less storage problem	5	3
Tasty	70	15
Conservation of rare variety	5	3
Drought tolerant	5	
High preference by consumer	15	2

Consumer preferences for mixed beans varied between Jumla and Humla. In Jumla, 21% of consumers liked the mixture because it looked attractive, while 60% favored

it for its taste. However, in Humla, only 3% appreciated its appearance and taste, with 24% of respondents indicating that they did not like mixed beans at all. This shows a distinct difference in consumer perceptions and preferences between the two districts.

Traditional System of Mixing Bean

In Jumla, 40% of farmers reported using the same method for mixing over the years, while 30% based their mixtures on experience and production, and 5% used selection techniques. In Humla, some farmers also followed the traditional method, while others preferred mixing early-maturing beans (Table 7).

In terms of bean preferences, 42% of farmers in Jumla preferred including "Kalo Male" in the mixture, followed by 29% who preferred "Kalo Sano." In Humla, 16% favored mixing "Kalo," followed by "Rato" and "Dalle Kalo." In Jumla, 51% reported modifying their mixtures by adding or removing landraces over time, while in Humla, only 12% made changes. Additionally, a significant portion of farmers 66.67% in Jumla and 64% in Humla—performed seed selection during seeding. During harvesting, most farmers in both districts—95% in Jumla and 91% in Humla harvested bean mixtures together in bulk from the same plot. In Jumla, 23% of farmers intercropped bean mixtures with other crops, whereas in Humla, 94% preferred intercropping, indicating a stronger reliance on mixed cropping systems in Humla.

Table 7. Percent respondents on mixing methods of landraces in cultivar mixture

Basis	Jumla	Humla
Selection based on insect/pest severity	5	3
Based on production	17	NA
Consultation with neighbor	12	NA
Based on fast growing and early maturing type	NA	18
Own experiences	27	NA

Market Values and Demand of Bean Mixture

The primary outlets for selling bean mixtures in Jumla and Humla are local markets and villages, with 54% of respondents in Jumla and 63% in Humla reporting these as their main selling points (Figure 4). Other market channels include retailers, sales through offices, and direct sales from homes. Notably, a barter system still exists in Humla, where some farmers exchange beans for other goods. The pricing of mixed beans varies between the two districts. A majority of respondents perceive mixed beans as cheaper, with 61.5% in Jumla and 94% in Humla stating this view. Conversely, 20.5% of respondents in Jumla reported higher prices for mixed beans, while 12% in both districts indicated that the prices are the same.

Demand for mixed beans differs significantly between the districts: 40% of respondents in Jumla noted a high demand for mixed beans, whereas 84% in Humla reported low demand. In terms of usage, 72.5% of Jumla respondents indicated that the harvest is primarily for dal and consumption, while 20% noted it is used for both selling and consumption. In contrast, all respondents in Humla stated that their beans are mainly for consumption. When it comes to taste preferences, all respondents in Jumla expressed a liking for the bean mixture, whereas only 27% of Humla respondents reported a preference for mixed beans. Additionally, while every respondent in Jumla described mixed beans as very tasty, only 39% of those in Humla shared this sentiment. This disparity in taste perception may influence the market dynamics and demand for bean mixtures in the two regions. Consumers in urban areas favor a mix of beans.

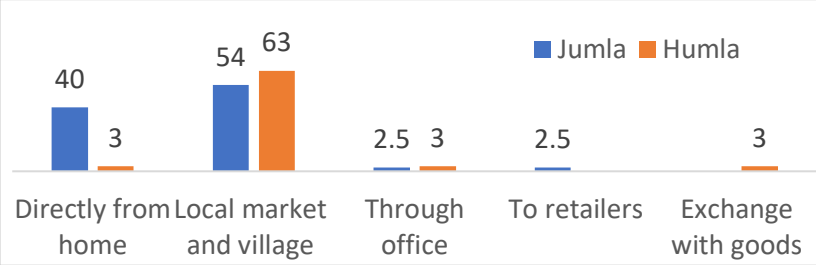

Fig. 4. Percentage of respondents for marketing beans in different market outlets

Advantages and Disadvantages of Bean Mixture

The majority of respondents highlighted that bean mixtures result in high production, taste, resilience to climate fluctuations, and reduced susceptibility to insect pests and diseases (Table 8). Additional advantages include easier marketing, improved soil fertility, better retention of soil moisture, and the presence of medicinal properties. Bean mixtures are also recognized for their drought tolerance, absence of storage issues, multiple harvest opportunities, and their role in conserving genetic diversity. Notably, 56% of respondents in Jumla and 58% in Humla indicated that the various bean varieties in the mixtures compensate for each other's production, thereby enhancing overall yields.

One of the most significant advantages of bean mixtures is the reduced risk of total crop failure. The survey revealed that the likelihood of complete crop failure is considerably higher when growing a single crop compared to a mixture. In Jumla, 63% of respondents reported complete failure in monoculture, while 90% stated there was no failure in mixed cultivation. Similarly, in Humla, 76% of respondents experienced complete crop failure in monoculture, whereas 15% reported no failures in their bean mixtures. This highlights the resilience offered by mixed cultivation, allowing farmers to maintain productivity even in challenging conditions.

Furthermore, bean mixtures are noted for their compatibility with maize cultivation, requiring less land and resulting in lower weed infestation. The conservation of rare landraces is another crucial advantage of growing bean mixtures. By maintaining genetic diversity, farmers foster the evolution of new genotypes, which can enhance resilience and adaptability. This practice can lead to increased profits, as reported by 11% of respondents in Jumla, who noted that if one variety fails, the other landraces can still yield produce. Bean mixtures are nutritionally superior and healthier compared to single landrace grains. They require less rainfall, making them a sustainable option for farmers in regions where water availability can be a concern.

Table 8. Percentage of respondent on advantages of bean mixture compared to sole culture

Feature	Jumla	Humla
Higher production from mixture	65	91
Less diseases in mixture	50	100
Less insect attack in mixture	42.5	100
Mixture gives good production even in marginal land and with low input	42.5	100
Less problem in storage of mixture	35	100
Mixture improved soil	98	61
Higher price of mixture	27.5	80
Better test of varietal mixture	70	100
Compensation in production if one landrace failed	56	58

The 5.4% of respondents in Jumla and 9% in Humla identified differing maturity periods among the bean varieties as a significant issue. This variation can complicate the harvesting process, as beans with different maturation times may require staggered harvesting, leading to increased labor and logistical challenges. In addition, farmers reported other problems, including difficulties in seed separation, insect infestations during heavy rainfall, and low market prices for mixed beans. Less than 5% in both districts reported difficulty to sale mix bean. Specifically, 10.8% of respondents in Jumla and 9% in Humla cited low market prices as a concern, while the challenges of insect infestation were mentioned in relation to adverse weather conditions. Despite these reported challenges, a majority of respondents indicated that they experienced no significant problems with bean mixtures.

Conservation of Genetic Diversity

In Jumla, 27 landraces of beans are conserved, while 12 landraces are preserved in Humla. Farmers cultivate a range of bean varieties, from a minimum of one to as many as seven landraces together. The variation in seed size, color, shape, plant type, and color across different landraces creates micro-environmental variations within

and around the plants and plots, enhancing the overall resilience of the agricultural system. The farmers' autonomous management of seed cycles demonstrates their deep knowledge of local varieties and ecological conditions. By maintaining and promoting landraces that exhibit high "ecological yield," the farmers prioritize not just grain output but other important factors like resilience to pests, diseases, and climate variability.

Ecological and Economic Benefits

Genetic diversity within a cropping system increases its ability to withstand biotic and abiotic stresses, reducing the risk of total crop failure. The diversity of landraces acts as a buffer against pests and diseases, as different varieties may possess varying levels of resistance (Zhu et al., 2000, Mundt, 2002, Castro, 2001, Koizumi, 2001, Petchey and Gaston, 2002). In particular, sole cropping of a single landrace can be devastating in the event of an outbreak of pests or diseases, whereas the mixture of landraces creates a more resilient system, reducing the likelihood of large-scale damage.

Conclusion

The tradition of cultivating bean mixtures, blending genetic diversity and traditional knowledge, has sustained mountain farming but is declining due to the rise of uniform varieties. Bean mixtures offer tastier, more nutritious beans that fetch higher market prices, however, farmers have reported low price in the market. Mixing landraces with similar maturity periods simplifies harvesting and ensures reliable yields, even in difficult conditions like drought or pest outbreaks.

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