

Vegetable Production Scenario in Trans-Himalayan Leh Ladakh Region, India

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ABSTRACT

The high altitude trans-Himalayan Ladakh region remains cut-off for over six months in a year due to heavy snowfall. Long harsh winters reduce the cropping season to just four to five months in a year. Single-cropping is dominant and agriculture production is entirely based on irrigation. The average land holding is small and emphasis has been on minimal use of off-farm inputs. Meeting the fresh vegetable requirement of the burgeoning local population, defence forces and the incoming tourists in this remote mountainous area is a formidable challenge. Very few vegetable types were traditionally grown in Ladakh. Significant progress has been made since 1960s in promoting vegetable cultivation in the region. The vegetable production scenario and consumption choices have undergone drastic changes, compared to what was available some decades back. Agro-techniques and vegetable production calendar in Ladakh differs from lowland parts of the country. Vegetable farms are smaller with an average 0.2 acre. The area of vegetable production constitutes 5.5 per cent of the total 10,319 hectares of agricultural land in Leh district. The widely grown vegetables were potato (75.6 per cent), peas (10.7 per cent), onion (3.4 per cent), cabbage (3.3 per cent), carrot (2.0 per cent) and cauliflower (1.8 per cent). Preference for potato, onion, cabbage and carrot was largely contributed to the desired long term storage capacity for consumption during the landlocked winter months. Supply to the army and tourism industry is the major factor for rapid transformation of vegetable production in the region. Critical areas that need focused attention include technology for vegetable production in winter months, post harvest management, seed production, organic certification, area expansion, harnessing niches and building stronger linkages between growers and consumers.

Keywords: Cold desert; Food security; Greenhouse; High altitude; Organic

1. INTRODUCTION

Vegetables have historically held a place in dietary guidance because of their concentrations of vitamins, minerals, dietary fiber and antioxidants¹. Accordingly diets with high quantity of vegetables are widely recommended for their health-promoting properties. Most countries have dietary recommendations of vegetables. The basic recommended quantity of vegetables for an Indian soldier at high altitude is 140 g potato, 60 g onion and 170 g fresh vegetables per head per day².

The high mountain region of Ladakh is characterised by a rugged topography at an average altitude of over 3000 m. It is separated from the Indian subcontinent by the Great Himalayan Range and edged by the Karakoram Range to the North³. The region is characterised by extreme temperature variations, low precipitation mostly in the form of snow, high wind velocity, sparse plant density, thin atmosphere with high UV-radiation and fragile ecosystem. The temperature drops down to -30 °C in winter⁴. Long harsh winters reduce the cropping season to just four to five months in a year. Single-cropping is dominant,

as double-cropping is possible only in a limited area falling below an altitude of approximately 3000 m. Agriculture production is entirely based on irrigation. The region remains cut-off for over six months in a year due to heavy snowfall. Availability of locally grown fresh vegetables is restricted to summer months and therefore, there are seasonal differences in dietary intake of food. The availability of fresh vegetable decreases significantly during the winter months, which has resulted in unbalanced diet. Micronutrient deficiencies including the lack of vitamin A, B6, B12 and folic acid are prevalent in the region. Seasonal shortfall and low dietary diversity among the local populace lead to micronutrient deficiencies, a phenomenon that has been described as 'hidden hunger'³. Self-sufficiency in food is an important issue for the region. Filling the gap between the required quantity and the quantity locally produce is a difficult task in this region. Importing goods to Ladakh necessitates the shipping of goods by truck across the Himalayas, with passes as high as 5300 m, covering the distance of Manali to Leh (480 km) or Srinagar to Leh (420 km)⁵. There is a growing demand for local vegetable produce due to population increase, urbanisation and growth in income. Therefore, meeting the increasing requirements

of fresh vegetable for the local populace and the army in this remote mountain area is a formidable challenge⁶. Against this backdrop, the purpose of this review aims to discuss the various aspects of vegetable production in Ladakh and to identify scope for further research.

2. VEGETABLE PRODUCTION SCENARIO

2.1 Early Vegetable Production

A limited variety of vegetables were traditionally grown in Ladakh. Before the practice of cultivated vegetable become popular in the region, people use wild plants such as *Allium prezewalskianum*, *Lepidium latifolium*, *Capparis spinosa*, *Urtica hyperborean*, *Lactuca dolichophylla*, *Fogopyrum tataricet* as vegetables⁷. The adventurous Moorcroft stayed for two years in Ladakh, from September 1820 to September 1822⁸. In his travelogue he stated⁹, ‘There is no great variety of vegetable produce in Ladakh, but onion, carrot, turnip, and cabbage are reared in some places during spring and summer. For winter use the leaves of the cabbage and turnip tops, or sliced turnip, are dried: caraway, mustard, and tobacco are grown in few gardens’. Cunningham⁸ in 1854 mentioned of peas and turnip being grown in Ladakh. Moravian missionaries came to Leh in last quarter of the nineteenth century. They brought with them vegetable such as potatoes, spinach, cauliflower, radish, green beans, kholrabi, brussel’s sprout and tomatoes. These were the first significant addition to the Ladakhi diet for many years¹⁰. However, cultivation remained restricted to fields of affluent families in few villages. Later on, after early 1960s when the Defence Institute of High Altitude Research (DIHAR), formerly FRL, was established in Leh, concerted efforts were done in terms of formal R&D to help improve the diversity and quantity of various vegetables in Ladakh region. Consequently, with the help of state functionaries like the State Agriculture Department, the agencies introduced and distributed seed and seedlings of different variety of vegetables in the region

Table 1. Vegetable crops introduced and seed/seedlings distributed to farmers in trans-Himalayan Ladakh by DIHAR

Year	Crop introduced
1965-1969	Beans, beet root, cabbage, cauliflower, carrot, lettuce, peas, onion, spinach, tomato, turnip
1971	Okra, knol-khol, leek, radish, sugar beet
1972	Chillies, coriander, cucumber, Chinese cabbage, mint
1974	Brinjal
1975	Garlic, methi, pumpkin
1980	Capsicum
1981	Karam-sag
1982	Bottle gourd, Squash
1995	Swiss chard
1997	Longmelon
2002	Celery, parsley
2003	Kale

Note: Data summarised from sale register of Defence Institute of High Altitude Research

(Table 1). Farmers training and extension activities were conducted extensively by the agencies to promote vegetable cultivation in the region. The locally produced vegetables and consumption choices are now far greater than what it was a few decades before.

2.2 Vegetable Production Data

The vegetable production data summarised in this study were obtained from a door-to-door survey of households in Leh district, in 2016. The vegetable survey indicates that the majority of vegetable farms are small. The average area under vegetable cultivation of the surveyed growers was 0.2 acre. Currently, the area of vegetable production constitutes 5.5 per cent of the total 10,319 hectares of agricultural land in Leh district. The district is divided into four belts viz. Leh, Sham, Nubra and Changthang based on altitude and valley. The largest area under vegetable cultivation is in Leh (52.6 per cent) followed by Sham belt (34.2 per cent) (Table 2). Total vegetable production in Leh district was 11,867 tonnes. Leh tops the vegetable production (55.4 per cent) followed by Sham (29.1 per cent), Nubra (13.4 per cent), and Changthang (2.1 per cent).

Table 2. Vegetable production in four belts of trans-Himalayan Leh Ladakh in year 2016

Belt	Vegetable production		Area	
	MT	Per cent	Ha	Per cent
Sham	3452	29.1	193	34.2
Nubra	1592	13.4	63	11.2
Leh	6572	55.4	297	52.6
Changthang	251	2.1	11	2.0
Total	11867	100	564	100

Note: Data summarised from survey conducted in 2016 in Leh district

A variety of crops are being grown by the farmers. The crops most widely produced were potato (75.6 per cent), peas (10.7 per cent), onion (3.4 per cent), cabbage (3.3 per cent), carrot (2.0 per cent) and cauliflower (1.8 per cent) (Table 3). Maintaining a diversity of crops has a purpose to meet the growers own requirement as well as to meet the diversified requirement of the consumers. In addition, diversity helps farmers to cope with any unforeseen situation affecting a particular or a bulk of vegetables. Preference for crops such as potato, onion, cabbage and carrot was largely because of its long term storage capacity during winter months when the region remains cut-off and open field cultivation is not possible.

There is a government campaign for the promotion of vegetable production in the region. Seed (Table 4), seedlings (Table 5) and farm implements are being distributed among the farmers. Incentives are being given to the farmers for construction of passive greenhouses, vegetable storage structures and compost pits. Farmers are also encouraged to adopt farm mechanisation and incentives are given to use plastic mulching. Local non-governmental organisations (NGOs) also joined in campaign for promotion of vegetable cultivation in the region.

Table 3. Production and area under different vegetables in trans-Himalayan Leh Ladakh (2016)

Crop	Vegetable production		Area	
	MT	Per cent	Ha	Per cent
Onion	402	3.4	37	6.6
Cabbage	397	3.3	21	3.7
Cauliflower	212	1.8	17	3.0
Carrot	242	2.0	23	4.1
Radish	95	0.8	6	1.1
Beans	40	0.3	12	2.1
Cucurbits	34	0.3	2	0.4
Potato	8970	75.6	253	44.8
Pea	1269	10.7	169	30.0
Others	206	1.7	24	4.3
Total	11867	100	564	100

Note: Data summarised from survey conducted in 2016 in Leh district

2.3 Agro-techniques and Production Calendar

Agro-techniques and vegetable production calendar in Ladakh region differs from those of other parts of the country (Table 6). Long harsh winters reduce the cropping season to just four to five months in a year. Single-cropping is dominant and use of passive greenhouse is widely practiced in the region. Average land holding is small where conventional cultural

practices such as use of pesticide, weedicide, mulching, staking, pruning, raised bed etc are not followed. Irrigation is done by flooding and crops are grown more densely than recommended.

Use of transplants and greenhouse cultivation are commonly practiced in Ladakh. Vegetable nurseries are raised in greenhouses from 21 March onwards and they become ready for transplantation from early May onwards. Raising of nurseries in greenhouses extend the crop growing season almost by two months which results in obtaining harvesting maturity of majority of vegetable crops. In contrast, nurseries raised in open field result in late transplanting and crops often fail to reach marketable stage. Direct seeding of summer squash, pumpkin and cucumber is widely practiced at DIHAR under black plastic mulch. Irrigation is done by flooding at three days interval during initial plant establishment followed by five days interval at later stages. A total of 20 to 25 irrigations are required to raise vegetable crops in summer. Turnip is among the first crop to harvest in the region, from May onwards. Crops such as knol-khol, summer squash and leafy vegetables reach marketable stage from late June onwards. Most of the crops reach harvestable stage from late July onwards and are harvested before October. Sub-zero temperature in October is not uncommon in the region, therefore, any delay in harvesting often results in frost damage.

Soil preparation and manuring is done in early October for raising leafy vegetables in greenhouses. Root transplanting

Table 4. Vegetable seed (quintals) distributed to farmers in Leh Ladakh by Agriculture Department, Ladakh Autonomous Hill Development Council, Leh

Year	Open Pollinated				Hybrid			
	Pea	Beans	Cabbage	Others	Onion	Tomato	Cauliflower	Others
2017	500	38	0.2	19.3	3.2	0.2	0.2	0.5
2016	450	0.3	0.2	19.3	3.2	0.1	0.1	0.3
2015	607	7.0	0.5	17.0	2.1	0.2	0.3	0.4
2014	480	-	0.2	15.6	2.0	0.1	0.2	-
2013	320	18.0	0.8	19.5	3.0	0.2	0.7	-
2012	349	0.2	0.7	14.7	2.0	0.3	0.3	0.2
2011	349	0.2	0.7	14.6	2.0	0.4	0.3	-
2010	518	23.2	0.5	17.3	1.7	0.3	0.1	0.3

Note: Data summarised from sale register of Agriculture Department, LAHDC Leh

Table 5. Vegetable seedlings (numbers) distributed to farmers and army units in trans-Himalayan Ladakh by DIHAR

Crop	Year						
	1975	1985	1995	2005	2015	2016	2017
Cabbage	2,41,425	1,99,575	2,90,170	79,325	1,38,200	2,19,700	2,24,700
Cauliflower	1,45,200	1,64,650	2,18,300	67,325	1,13,900	1,52,620	1,77,200
Khol-khol	46,500	22,250	80,250	6550	29,600	14,100	28,200
Onion	1,31,775	2,84,475	2,76,650	2,81,200	4,26,400	7,07,540	11,76,100
Tomato	79,000	1,00,075	54,350	77,183	2,15,700	1,66,800	2,54,200
Others	850	800	3,100	30,696	1,03,429	1,62,813	1,66,394
Total	6,44,750	7,71,825	8,68,470	5,42,279	10,27,229	14,23,573	20,26,794

Note: Data summarised from sale register of Defence Institute of High Altitude Research

Table 6. Year round calendar of agro-techniques for vegetable production in trans-Himalayan Ladakh

Activity	Period*	Greenhouse	Open field
Manuring and soil preparation	15-25 March	√	
	April		√
Seed sowing	21-30 March	√	
Nurseries ready for transplant	Early May	√	
Manuring and soil preparation	Mid to late May	√	
Transplanting	10-25 May	√	√
Weeding	Early June, early July	√	√
Harvest	Late June to late September	√	
	Late June to late November		√
Manuring and soil preparation	Early October	√	
Sowing and transplanting (leafy vegetable)	Mid October	√	
Weeding	November	√	
Harvest (leafy vegetable)	December to early March	√	

*The dates may vary from place to place depending on climatic conditions

of spinach is often practiced. Crops such as celery, coriander, parsley and lettuce are raised by direct sowing. Indian spinach (*Beta vulgaris*) is most widely grown crop in greenhouses and in general two harvests are obtained, first in mid December and second in early March⁶. Irrigation is done at 30 to 40 days interval.

2.4 Seasonal Availability of Vegetables

Climatic condition of the region restricts growing season of crops from May to September in open field condition (Fig. 1). Vegetables are generally harvested from June to September while crops such as potato, onion, cabbage, carrot etc are harvested in late August to September. The region sees a glut of vegetable during the period which in contrast to an acute scarcity of fresh vegetable in winters. During winter passive solar greenhouse cultivation is the only source of locally produced fresh leafy vegetables (Fig. 2). Crops such as potato, radish, carrot, cabbage, onion and turnip are stored in underground pits and root cellars for their consumption in winter months¹¹. With the integrated use of greenhouse technology and zero energy storage techniques, it is now possible to make fresh vegetables available throughout the year (Table 7).



Figure 1. Tomato crop in open field in Ladakh during summer.

2.5 Growing Demand for Local Vegetable Produce

Vegetable production in Ladakh has increased by leaps and bounds during the last three decades primarily due to technological intervention, access to farm inputs and population growth. The population of Leh district has increased from 40,000 in year 1951 to 1,47,104 in year 2011. In addition to the army, Ladakh's floating population is increasing rapidly. The number of tourists visiting Leh district has increased significantly between the years 1991 and 2016. Educational campaigns by various government and non-government organisations have resulted in increased awareness among the inhabitants about the significance of fruits and vegetable in daily diet. Apart from growing vegetables for self consumption, supply to the army and the tourism industry is a major factor for rapid transformation of vegetable production in

the region. Marketing of vegetables, especially potato, peas and turnip, to other parts of the country is also being explored in recent years.

2.5.1 Army Supply

There is a large number of military troops stationed in Ladakh due to strategic nature of the region. Providing essential nutritional support to the army operating in high altitude are best taken from resources available locally as timely supply of fresh vegetables from low land is not always possible due to logistics constrains⁶. There exist mechanisms to supply fresh vegetables to the army directly from the farmer's field through the farmers' cooperative marketing societies². Therefore, supply of vegetable to army has emerged as major market to the local farmers in this remote mountainous region.



Figure 2. Leafy vegetable in trench greenhouse during winter in Ladakh.

Table 7. Commercially grown vegetables and their availability in trans-Himalayan Leh Ladakh

Crop	Recommended variety	Seasonal availability		
		Greenhouse harvest	Field harvest	Zero-energy stored
Beans	Contender, Pusa Himlata	-	Jul-Sept	-
Beet root	Crimson Globe, DDR	-	Jun-Sept	Oct-Mar
Bottle gourd	Shramik, Pusa Naveen	-	Jul-Sept	Oct
Brinjal	Pusa Purple Cluster, Pusa Purple Long, Janak	Jul-Nov	Aug-Sept	-
Broccoli	KTS-I, Fiesta	-	Jul-Sept	-
Brussel's Sprout	Hields Ideal	-	Jul-Sept	-
Cabbage	Golden Acre, PDH, KGMR-1, Megaton, Gonzales	-	Jul-Oct	Nov-Mar
Capsicum	California Wonder, Pusa Deepti, KTCPH-3, Aishwarya	Jul-Nov	Aug-Sept	-
Carrot	Nantes	-	Jul-Oct	Nov-Mar
Cauliflower	Amazing, Shentha	-	Jul-Sept	Oct-Nov
Celery	Trimmuf	Dec-Apr	June-Sept	-
Chillies	Pusa Jwala	Jul-Nov	Aug-Sept	-
Chinese Cabbage	Optiko	-	-	-
Coriander	Caribe	Dec-Apr	Jun-Sept	-
Cucumber	Japanese Long Green, Pusa Sanyog, BSS-718	Jul-Nov	Aug-Sept	-
Garlic	Agrifound Parvati	-	Jul-Oct	Nov-Mar
Knol-khol	White Vienna, Pusa Virat	-	Jun-Sept	-
Methi	Kasuri	-	Jun-Sept	-
Mint green	FRL Selection	Nov-Apr	May-Oct	-
Onion	Liberty, Brown Spanish, Red Coral	-	Jul-Oct	Nov-Mar
Peas	Arkel, Lincoln, Pusa Pragati	-	Jul-Sept	-
Potato	Kufri Chandramukhi, Kufri Jyoti	-	Aug-Oct	Nov-Mar
Pumpkin	BSS-718	-	Aug-Sept	Oct-Nov
Radish	Pusa Himani, Gya Labuk	-	Jun-Oct	Nov-Mar
Red Cabbage	Primero	-	Jul-Sept	Oct-Mar
Indian spinach	Delta	Dec-Mar	May-Oct	-
Summer squash	Australian Green, Pusa Alankar	-	Jun-Sept	Oct-Nov
Tomato	Tolstoi, Sultan, Roma, Marglobe	Jul-Nov	Jul-Sept	Oct-Nov
Turnip	PTWG	-	Jun-Sept	Oct-Dec

2.5.2 Tourism

The number of tourists visiting Leh district has increased significantly from 9,055 in year 1991 to over 2,40,000 in year 2016. Tourism has influences the production of vegetables in several ways. It created incentives for local farmers to expand and diversify their vegetable production to meet tourist food demand, generated agricultural employment by attracting farm labour, and at the same time reduced the availability of agricultural land through an increased use of agriculture land for creating tourism infrastructure. Tourists, especially those staying in family run guest houses and homestays, are hugely impressed by locally produced quality organic vegetables. However, most of the vegetable for tourist consumption still continue to be imported due to seasonal shortfall and lack of proper linkage between the growers and the buyers in tourism industry. There are several reasons that hotels do not use a greater proportion of local vegetable produce: (a) farmers lack

the information on types and quantities of vegetable needed by hotels and restaurants, (b) imported vegetables appear to be cheaper than local vegetable produce, and (c) farmers are unable to comprehend the day-to-day demand schedule of the hoteliers. Stronger linkages are required between growers and the buyers in tourism industry so that growers can adapt themselves and also benefit from the flourishing tourism trade in the region.

2.6 Women in Vegetable Production

In almost all contexts of vegetable production in Ladakh, women play a decisive role in the Ladakhi society. Women constitute a substantial portion of the labour input in vegetable production. Vegetable farms are largely managed by the women and they are directly involved in selling of the vegetable produce in the local market. There is an appreciable participation by women folks in various training and extension

activities conducted by agencies. Between year 2012-2016, women constitute 71 per cent of the farmers who participated in various training and exposure programs conducted by DIHAR. The technical know-how gathered during such programmes by the women folks empower them and take the decision making role in vegetable cultivation, which in turn plays a major role in a household's financial contribution.

2.7 Harnessing the Niche

Ladakh as a region enjoys certain advantages over the plains due to its topography and agro-climatic conditions. Off-season vegetables are being grown that cannot be produced in the plains during the summer. Disease and insect infestation are also minimal, therefore, the vegetable produce are free of chemical pesticides. The use of chemical fertilizer is minimal making the produce much safer to handle. The farming practices are traditionally based on ecologically sound recycling of nutrients and sustainable soil and crop management system. Irrigated with mineral rich glacial water, the vegetables from Ladakh are naturally tastier. The region is also an ideal place for vegetable seed production due to low humidity, bright sunshine, and low incidence of disease and insect pest infestation. There is an immense scope for harnessing these niches that can hugely benefit the local population. Long term planning is required with a matching infrastructure in place to benefit from niche advantages. Without infrastructural support, niche harnessing is not only ineffective, it can be harmful as it requires higher investment, greater input, and makes the farmers dependent on exchange options¹².

2.8 Characteristic Features of Vegetable Production in Ladakh

Topography and climatic conditions of Ladakh and the cultural ethos of the people living in the region makes some of the vegetable production features unique in the country. Some of the characteristic features are:

- Single cropping is dominant in the region. Vegetable cultivation in open field is feasible only during summer months i.e. from May to September. During winter months, not even a single green leaf can be seen in open fields due to sub-zero temperature.
- A variety of vegetables can be grown in summer. DIHAR has demonstrated feasibility of growing 101 types of vegetables in a single season in the same field. This remarkable feat has also been recorded in Limca Book of Records.
- Growing a giant size vegetable is not uncommon in Ladakh. DIHAR is also in Limca Book of Records for growing of extra large size of vegetables (pumpkin 35 kg, cabbage 14.2 kg, turnip 4.3 kg, knolkhol 3.2 kg, potato 1.1 kg, onion 750 gm).
- Almost every household in Ladakh owns a greenhouse that produces leafy vegetables during winter months.
- Transplants which are mass produced under greenhouse are commonly practiced in Ladakh. It extends the cropping season nearly by two months.
- Minimal use of off-farm inputs is a distinctive feature of Ladakhi agriculture. The vegetable farming practice

is traditionally based on ecologically sound recycling of nutrients and sustainable soil and crop management system.

- Standard agricultural practices such as use of pesticide, weedicide, mulching, staking, pruning, raised bed etc are not followed. Crops are grown more densely than recommended.
- Vegetables from the region are free of pesticides due to minimal disease and insect infestation.
- Agriculture production is entirely based on irrigation. Water is the main limiting factors for expanding area under cultivation.
- In the context of vegetable production, women play a decisive role in the Ladakhi society.
- Vegetables are sold directly to consumers. Selling through middlemen is a rare phenomenon in the region.
- Army is the main buyer of vegetables produced in the region.
- The climatic condition of Ladakh is ideal for vegetable seed production.

2.9 Research and Development for Further Innovations

Significant progress has been made since 1960s in promoting vegetable cultivation in Ladakh. Major focus have been on growing vegetables during summer, identification of suitable varieties, greenhouse cultivation during winter, early raising of vegetable seedlings, and storage of selected vegetables during winter months. The following priority areas need a focus attention in coming years:

- (a) *Fresh vegetables in winter*: Availability of fresh vegetable during winter months is restricted to leafy vegetables and selected tuber and root crops. Further research is required to increase diversity and quantity of local vegetables for the winter months.
- (b) *Seed production*: The climatic condition of Ladakh is ideal for vegetable seed production. Lofty mountains that separate the villages serve as natural barrier to cross pollination. However, commercial vegetable seed production in Ladakh is still at infancy. Focus attention is required towards building human resources for production of high value vegetable seeds in the region.
- (c) *Greenhouse*: Greenhouse cultivation is popular in Ladakh. Almost every household in Ladakh owns a greenhouse. However, majority of the greenhouse are small in size and are designed to meet the vegetable requirement of a small family. The design of existing greenhouses is such that they can be used only from October to May. There is a need to promote large scale commercial greenhouses on the vast barren land in Ladakh. New greenhouse designs should focus on making the greenhouses functional throughout the year.
- (d) *Post harvest management*: Majority of the vegetable crops attain harvesting stage in August and September. In view of perishable nature of the produce, excess produce gets spoils. Growers, therefore, restrict growing of perishable vegetables on small areas. Storage inadequacies results in limited vegetable production. There is need to promote

food processing industries to make available local produce during winter months. Food processing in the region is limited due to insufficient technical expertise.

- (e) *Harnessing niches*: Ladakh region has some comparative advantages over the plains. However, the niches have not been harnessed till date. Suitable infrastructural support needs to be developed to harness the niches.
- (f) *Contract farming*: A variety of off-season vegetables such as broccoli, asparagus, peas, cabbage, cauliflower etc are being grown that can be marketed to other parts of the country. Contract farming need to be introduced especially for exotic vegetables on large scale to meet the demand of niche market.
- (g) *Advanced production technology*: Vegetable growers in Ladakh face many challenges and there is a need to invest in development of new and innovative production technologies. Improved production technologies are necessary to enable the farmers to remain on the farmland and to produce vegetable against increasing challenges brought on by the changing society and the harsh weather¹³. Plasticulture is a proven technology that needs to be promoted among the growers. Farmer training and extension activities are required for achieving efficiency. Farm mechanisation is required to combat labor scarcity especially during critical farm activities¹⁴.
- (h) *Organic produce*: Minimal use of off-farm inputs is a characteristics feature of Ladakh agriculture. Standard cultural practices such as use of pesticide and weedicide are not followed. Efforts are required to replace the use of chemical fertilizer in vegetable production. Organic certification is required to fetch higher prices for the farm produce. There is a need to link organic farming with tourism industry.
- (i) *Water conservation*: Water is the major limiting natural resource for agricultural activity in Ladakh. More attention should be paid in adopting technologies to reduce water wastage due to runoff and evaporation.
- (j) *Cultivation on barren land*: There is immense scope to expend area under vegetable cultivation from the existing 564 hectares. The vast area of barren land remains unused. With technological advancement, it is now feasible to lift water from the river for irrigation. The glacial water that drains into the rivers need to be conserved and judiciously used to bring more area under cultivation.

3. CONCLUSIONS

Meeting the fresh vegetable requirement of the burgeoning local population, the army and the visiting tourists in the remote mountainous Ladakh region is a formidable challenge. Seasonal shortfall and low dietary options prompt to micronutrient deficiencies, a phenomenon that has been described as 'hidden hunger'. Significant progress has been made since 1960s in promoting vegetable cultivation in Ladakh. The vegetable production and available consumption choices are now far greater than three decades back. However, most of the vegetable requirements still continue to be imported due to seasonal shortfall and lack of proper linkage between the growers and consumers. Important areas that need focus

attention include vegetable production during winter, post harvest management, seed production, organic certification, area expansion, harnessing niches and building stronger linkages between growers and consumers. This will lead to sustainability of the region in the context of vegetables.

Conflict of Interest: None

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