Annals of Arid Zone 54(3&4): 1-12, 2015

Achieving Sustainable Livelihood in Cold Arid Regions of India through Multienterprise Options

R.K. Bhatt, M.S. Raghuvanshi and Rajwant K. Kalia*

ICAR-Central Arid Zone Research Institute, Jodhpur 342003, India

Abstract: The cold arid zone of India being located in the rain shadow of Himalayas is one of the driest regions in the world. The area remains inaccessible to the outside world for nearly six months in a year due to heavy snowfall. This fragile ecosystem with limited availability of natural resources is a growing attraction for tourists. Multi-enterprise option needs to be strengthened for the upliftment of the socio-economic status of the region. Integrated farming systems combining fruit and fodder trees with medicinal plants into the cropping system can address the problems of conservation of medicinal plants as well as can ensure assured income to the farmers. Organic farming, protected cultivation, off season vegetable production, value addition and development of better storability methods for vegetables and fruits will be remunerative to the farmers of cold arid region. Animal husbandry is another important component of subsistence agriculture. The Ladakhis raise cattle, sheep, goats, horses and Dzo (cross between yak and cow), as primary source of milk, meat, wool and other byproducts. Mostly sheep and goats are reared for wool, milk and meat purpose. Pashmina and Changthangi goats are reared for fine grade Pashmina wool. Cold water fish production has emerged as an additional source of income generation in the region. Tourism is also emerging as an important source of economy providing jobs to thousands of people. Strengthening of all such enterprises can ensure livelihood security to the local population of cold arid region in addition to conservation of this unique ecosystem and cultural heritage.

Keywords: Cold arid zone,

Indian cold arid region in the trans-Himalayan zone, constitute about 7.1 Mha and is confined to Ladakh (J&K), Lahaul and Spiti (HP) and small pockets in Uttrakhand (Niti and Mana) states. Ladakh (*Land of high passes*), comprises Kargil and Leh districts covering geographical area of 96,701 km^2 accounting 87.4 % of the cold-arid region of India (Sharma, 2000). Leh district is geographically located between 32°N to 36°N latitude and 75°E to 80°E longitude at an altitude ranging from 2900 to 5900 m above mean sea level (Ali *et al*., 2012). The cold arid part of Ladakh is characterized by huge seasonal fluctuations in temperature ranging from +30°C to -30°C with maximum sun shine days. It is one of the driest regions in the world with low rainfall, however, maximum precipitation is received in the form of snow which becomes the major source of water for livelihood support in the region. Intensive sunlight, high evaporation rate, strong winds and fluctuating temperature, characterize the general climatic conditions. The area is inaccessible to the outside world for nearly six months in a year (Angchuk and Singh, 2006). It is a fragile ecosystem with a complex variability in climatic and geomorphological processes with limited availability of natural resources impacting livelihoods of indigenous communities. The soil and the climatic conditions allow a very short growing period which extends from May-September in general. The soil having sand and gravel is not very productive, having low water holding capacity and poor nutrient status. Water resources are minimal with glacier-fed streams being the only source of irrigation. The unique pasture lands of Changthang, Zanskar, Suru, Drass and Nubra Valleys of the region are used for grazing of sheep, pashmina goats and yak. The region is usually sparsely inhabited. Main sources of income include rearing of goats, sheep, yak and traditional agriculture. Tourism in the form of camping, tracking, rafting and culture is presently the main focus of the people of this region. Multi-enterprise option needs to be strengthened for the holistic development and improvement of the socio-economic status of the local population in this region and to minimize the movement of people to lesser harsh environments for better economic

*E-mail: rajwant.kalia@icar.gov.in

Fig. 1. Village settlement and terrace cultivation.

benefits. This will also ensure conservation of indigenous traditional knowledge and culture.

Multienterprise Options

Crop production and diversification

In the cold arid region of Ladakh, only 2.64% area of Leh, Nubra and Nyoma is arable and 9.66% area is under vegetation cover. The arable land is restricted to flat valleys and lower slopes where water availability is ensured. The traditional crops of the region include barley (*Hordeum vulgare*), grim (*H. aegiceras*), wheat (*Triticum aestivum*), buckwheat (*Fagopyrum tataricum* and *F. esculentum*), millets (*Panicum miliaceum*) and oat (*Avena sativa*). Small cropped area is also occupied by pea (*Pisum sativum*), potato (*Solanum tuberosum*) and mustard (*Brassica* spp.). *Allium cepa, A. stracheyi, Coriandrum sativum* and *Carum carvii* are mostly cultivated in kitchen gardens and are used as spices. Despite short growing period, absence of rainfall, harsh climatic conditions, the Ladakhi people have developed a range of farming systems and produce more than enough food for themselves. Traditional agriculture is based on human labor, animal power and handmade tools. Only one crop can be harvested each year. Naked barley (*Hordeum vulgare*) is the main staple food crop complemented by wheat (*Triticum aestivum*). The latter is grown at altitudes less than 3600 m. Cultivation of green pea (*Pisum sativum*) which recently began in the Spiti catchment is rapidly replacing traditional crops. Similarly large scale potato cultivation has marginalized traditional staple crops in Lahul region, northwest of Spiti catchment. Snow melt flows are used for irrigation in higher altitudes where subsurface water resources are inadequate. Crops like barley are sown in May and reaped in July; however, the growing time varies considerably with altitude. In recent years farmers have diversified their agriculture by including vegetable crops like cauliflower, (*Brassica rapa*), cabbage (*B. oleracea*), *B. nigra, B. caulorapa, Chenopodium album, Cucurbita maxima, Cucumis melo, Solanum lycopersicon, S. melongena* and *S. tuberosum* under cultivation. They use these crops for self-consumption as well as for sale to army personnel. Additionally many legumes associated with agricultural crops act as valuable sources of fodder and soil enrichment (Butola *et al.*, 2012).

Because of hilly terrains and slopes, all the agricultural fields are in terraces and therefore it is also called terrace cultivation (Fig. 1). The human settlements and agricultural cultivations are situated only on the sides of rivulets/water streams, gullies and banks of Sindh. Cultivation of the field is also a unique system in the hilly tracts of the country and most of the agricultural works are carried out manually. In Ladakh male Dzo (a cross of cow and yak) is used as draught power for field operations. During ploughing, the family members usually sing songs in front of Dzo so that this animal works smoothly. Harvesting, threshing and transportation of crops are also done manually. Tractor operations are increasing in some parts of the region due to scarcity of laborers. Climate change in the Himalayan belt poses new challenges to

agriculture and food security in the region. The area under traditional cultivation of naked barley is decreasing because of limited marketing of the produce. Therefore, there is an urgent need to diversify agriculture with multi-cropping, improved varieties and technologies, assured marketing with remunerative benefits for sustaining the livelihood in cold arid regions. Off season peas produced in Lahul and Spiti valley are directly transported to the Azad Mandi vegetable market at Delhi making them an attractive source of income generation in the region. Similarly, quality potato production can be taken up on large scale. Such assured marketing and remunerative prices can promote the cultivation of these crops on large scale in cold arid regions.

Organic Farming

Organic farming is the major form of agriculture in this region, adopting the techniques of crop rotation, green manuring, compost and biological pest control. Because of poor road connectivity in the region, farmers have developed some unique ways of crop cultivation. To maintain sustainability of crop production, farmers use the organic matters to manure their agricultural fields. Farm yard manure and night soil are the two major sources for organic farming which is popularly used in Ladakh. Night soil, a unique organic matter source is used only in Ladakh. The local bathroom where night soils are conserved to be used as organic manures in the field are called Chaksa (Hussain *et al*., 2012). Organic farmers integrate cultural, biological, mechanical and physical methods to manage weeds. With the help of Ladakh Autonomous Hill development Council (LAHDC), organic pits are used to grow organic manure for which sufficient subsidies are provided. All the horticultural crops are also grown organically with biological control of pests and diseases. Fodder production is also organic in nature therefore, organic milk production can open another source of income generation. Cultural heritage also support and promote the organic cultivation in the region. The market for organic products is increasing in the country and therefore, the hilly states particularly the cold arid region of Ladakh can be one of the potential source of organically produced offseason crops like, potato, peas, wheat, barley and other vegetables.

Integrated Farming Systems

Integrated farming systems at small scale have been adopted by farmers in this region. In this system, the main staple food crops like naked barley is grown in the major area of the agricultural field, the remaining part is used to raise wheat, buckwheat, pea, etc. establishing field-crop-based farming systems surrounded by trees of *Populus* and *Salix* for fuel and fodder. On the bunds the perennial fodder crop, alfalfa (*Medicago falcata*) is grown for livestock. Vegetable crops like, turnips, potatoes, tomatoes and lettuce are grown in kitchen garden along with the fruit trees like apricot, apple and walnut. Traditional farming systems promote both species and genetic diversity. The farmers have been conserving landraces of cultivated plants with reservoir of genes especially of crops such as alfalfa and barley, which are of global importance. Rich diversity has been collected from Ladakh for naked (hull-less) Barley (Singh, 2009). The integrated farming systems are mainly composed of agricultural and livestock husbandry sector. In the unique environment of the cold arid region, this can be the sustainable option for the livelihood support to the farmers. This approach also generates employment round the year however, it requires improving the local skills with establishment of small scale entrepreneurships to help local inhabitants to tap the commercial possibilities in this sector.

The major dominant and sustainable IFS models can be:

1. Crops (barley/wheat + peas) + alfalfa on field bunds and fallow lands + livestock
2. Potato + food crops/peas + alfalfa on field bunds and fallow lands + livestock
3. Trees (populus/salix) on filed boundary/ channels + crops/potato/peas + alfalfa on field bunds and fallow lands + livestock
4. Fruit trees/fodder and timber trees + food crops + vegetables + alfalfa on field bunds and fallow lands + livestock.
5. Fruit trees/fodder and timber trees + vegetables + alfalfa on field bunds/fallow lands and grazing lands + livestock

Agroforestry Systems

In Ladakh region, traditional agroforestry system in the form of agri-silviculture system

Fig. 2. Salix and Populus based agroforestry systems.

exists since times immemorial. Agriculture fields usually have boundary plantations of multipurpose trees of willow (*Salix* spp.) and Popular (*Populus* spp.). Almost all the settlements in the Leh, Kargil and Nubra valley are covered with willow and popular which are the main source of fuel, fodder and timber. In this system the farmers produces food, fodder, fuel and timber from same unit of land (Fig. 2). These species also contribute approximately 400 tons of leaf litter to the ground and thus are great source of organic carbon responsible for sequestration of more than 75,000 tonnes of carbon (Kumar *et al*. 2009a). Silvipastoral systems consisting of *Populus* and *Salix* trees along with alfalfa and other local grasses are the dominant systems as the demand of timber and fodder is very high. Sea buckthorn (*Hippophae rhamnoides*) widely grow on field boundaries and slopes provide fuel, fodder, medicine and fencing of fields. Due to its nitrogen fixing ability, it rehabilitates soil in addition to supporting agricultural crops. The major dominating agroforestry systems existing in the Ladakh region are:

1. *Populus* + food crops/potato/vegetables/ fodder crops
2. *Salix* + food crops/potato/vegetables/fodder crops
3. Apricot/apple/pears/walnut + food crops/ potato/vegetables/fodder crops
4. Underutilized shrubs (Sea buckthorn) on field slopes/boundaries + food crops/potato /vegetables/fodder crops (alfalfa)

Major limitations to the agroforestry system include availability of quality planting material and limited knowledge of propagation and plantation agro techniques. These systems further need to be studied from tree-crop interaction point of view and also economics of the system needs to be worked out to make it a sustainable enterprise for the region.

Horti-agri System

In Ladakh region apricot production is considered one of the economically viable option having direct influence on the socio-economic upliftment of the farming communities of the region. In some part of cold arid region apple, walnut, pear, peach and plums are grown as sole crop for commercial production. Apricot is associated with tradition and culture of this cold arid region (Dwivedi *et al*., 2007); almost every part of the fruit is used by the local inhabitants. Ripe apricot is an excellent dessert fruit and is used for table purposes. These fruit trees are grown as sole orchard, on field bunds of agricultural crops, under horti-agri, horti-pasture, silvi-horti-agri (food crops/vegetables/ medicinal plants) and pasture systems to produce food, fodder, fuel and timber from the same unit of land and also traditionally grown in kitchen gardens in this region (Butola *et al*., 2012). Apricot is mostly grown in Leh, Kargil and Nubra valley on commercial scale. This is one of the major sources of income and employment generation in the region. The total production of fresh apricot fruits was 8806 tons in Ladakh (Kashmir Life, 2012) with 3606 tons in Leh district and 5200 tons in Kargil district (Kaur, 2012) for the year 2010-2011. This fruit crop is one of the major sources of income and employment generation in the Ladakh region.

Sea buckthorn (*Hippophae* L.) commonly known as Leh berry or Siberian pineapple, is an economically and ecologically important medicinal plant found in this region. It is a fast growing, frost, wind and heat-resistant plant highly adaptable to extreme climatic conditions, commonly known as 'cold desert

Fig. 3. Naturally growing sea buckthorn, collection and primary processing in Leh.

gold' due to its high potential as a bio-resource for land reclamation, reducing soil erosion and other uses. Many products have been developed from its berries, leaves and bark. Processed products include: oil, juice, alcoholic beverages, candies, ice-cream, tea, jam, biscuits, vitamin C tablets, food colors, medicines, cosmetics and shampoos. As per various reports sea buckthorn berries are the most nutritious and vitamin-rich fruits among the plants. Sea buckthorn is also rich in proteins especially globulins and albumins, fatty acids such as linoleic and linolenic acids and free amino acids. The leaves are an equally rich source of important antioxidants. In addition to its carotenoid and vitamin E content, the oil from the sea buckthorn berries contains on average 35% of the rare and valuable palmitoleic acid (16:1n-7; Omega-7 series fatty acid). This rare fatty acid is a component of skin fat and is known to support cell, tissue and wound healing. Seed oil contain approx. 31.2% protein, 88.3% - 89.1% unsaturated fatty acids, particularly linolenic acid (32.3%), linoleic acid (40.8%), and oleic acid (15%) (Kalia *et al*., 2011).

The wide adaptation, fast growth, strong coppicing and suckering habits coupled with efficient nitrogen fixation ability (*Frankia-actinorhizal* association) make sea buckthorn well adapted for soil conservation, soil improvement and marginal land reclamation. Sea buckthorn may be very valuable for promoting wildlife and animals use it for food and shelter. It is also used as live fencing around the agricultural field and orchards and on the river side for soil conservation purpose (Kalia *et al*., 2011). It is widely occurring in Leh and Nubra valley. So far it has not been domesticated for cultivation as fruit species but is naturally growing widely in all kind of soils in the region. Farmers of this region collect the berries and sell it to the processing centers (Fig. 3). As per discussion with the farmers, collection of berries is very cumbersome because of spiny bushes. They need techniques and machines to collect the fruits so that more produce may be made available in the market. Dihar lab at Leh has developed large number of products from its berries, leaves and bark which needs proper commercialization and marketing. Therefore, small scale processing and value addition centers should be established to commercialize the produce at a large scale.

Off Season Vegetable Production

Earlier vegetable production in the Ladakh region was negligible. But with increasing demand due to tourism, defence activities and food habit of local inhabitants, the scenario has changed and now days every household is growing vegetables in their kitchen gardens for self-consumption as well as for marketing (Fig. 4). From need driven to market driven, Ladakh has come a long way in vegetable consumption. Today total area under vegetables in Leh district is 310 ha with the production of 75.44 tons and in Kargil district it is 216 ha with a production of 49.77 tons giving total production of 125.21 tons. Average productivity of vegetables is 0.124 tons ha^{-1} (Wani *et al*., 2011)

which require further improvement. Various vegetables which are successfully cultivated here include cabbage, cauliflower, knol khol, broccoli, kale, radish, turnip, carrot, beet root, beet leaf, spinach, karam saag, fenugreek, coriander, pea bonnevillae, arkel, lincoln, french bean, onion, garlic, celery, lettuce and potato.

Extensive demand of potato from the defence sector led to introduction of new varieties in the region and area under cultivation also increased tremendously. Processing and storage techniques are urgently required for making the vegetables available during the winter season. Traditionally potato is harvested manually and processed for storage. Due to temperatures falling below zero degree during the winters, potatoes are buried in the soil or are stored in underground rooms covered with soil (Fig. 4). Off season vegetable production could be remunerative to the farmers of cold arid region. Peas from Lahaul and Spiti are directly transported to the Azad mandi, Delhi in summer season as there is increasing demand in the market. Keeping in view the regular demand, there is a need to strengthen marketing initiatives at community level. Cooperatives with strong networks within and outside the district should be promoted. Apart from this off season vegetable seed production can be another possibility to generate additional income for the farmers of this region. This unexplored area needs due attention. Vegetable production is an advantageous option having sufficient scope for value addition and commercialization.

Protected Cultivation

Protected cultivation using polyhouse technology is useful for vegetable production in the cold arid region. Protected cultivation is a well-defined sustainable technology for off season food production in attaining nutritional security (Akbar *et al*., 2013). Various agencies are engaged in the research and development of protected cultivation of vegetables particularly during freezing winters to augment fresh food supply to the inhabitants. Many naturally ventilated zero energy polyhouses have been tried and tested for the region. Vegetable production system in the cold arid region during the freezing winters can be well achieved by protected cultivation technology (Kanwar and Akbar, 2011). Vegetable crops like tomato, binjal, okra, peas, capsicum, cabbage, spinach and cucurbits etc. can be grown under protective cultivation. As reported, many types of greenhouses have been tried in the region by various agencies (Singh *et al*., 2008) viz. LEHO-type greenhouse (Kanwar *et al*., 2011), local poly house, Chinese type polyhouse and mud walled poly houses. Trench and plastic low tunnel are the cheap protected cultivation technologies in operation in the cold arid region for raising nursery. The trench and polyhouse (local design) have been largely adopted by farmers due low fabrication cost and easy operation. The demand of vegetable in the local market is increasing therefore, protected cultivation is one of the viable options for improvement of the economy of the farming communities of the region.

Fig. 4. Vegetable cultivation in kitchen garden and storage for winter season.

Value Addition

Vegetables

Growing season for crops, vegetables and fruits is very short in the cold arid region and the region remains cut off from rest of the country for more than six months during winters and therefore, the region has to depend on stored products during this period. However, storability remains a major problem therefore, value addition is the only option to get better market price. If the vegetables are processed and stored in dried form then they can meet the demand of vegetables during off season when fresh vegetables are not available.

Apricot fruits

The major fruit of cold arid region, particularly of Ladakh is apricot. Dried apricots are the only horticultural product which has a demand outside the Ladakh region (Mir, 2000). Solar energy, available in ample quantity is used for apricot drying in the region using open sun drying or solar driers. Locally processed and dried apricots are of poor quality thus, there is need of suitable processing and value addition which will give it better marketability. Introduction of different types of solar dryers for drying as well as sulphur fumigation (sulphuring), dipping in potassium metabisulphite (KMS) solution (sulphiting) and osmotic dehydration before drying have added to its acceptability and market value (Hussain *et al*., 2014). Different types of solar dryers are used in Ladakh as per their capacity and drying periods viz., Tent dryer, Solar cabinet dryer, Solar polyhouse dryer, Sunbest solar dryer, Metallic solar dryer and PEN solar dryer (Hussain *et al*., 2014). Drying and processing of apricot with newer technologies will widen its marketability. There is an urgent need to revitalise the technologies available for the development of horticulture industry in Ladakh and ensuring sustainability of livelihood in the cold arid region.

Barley

Naked barley is the major staple food and is grown on large areas by the farmers. They use it for making number of local food products for immediate consumption as per their food habit. Local beverage called *chhung* is also prepared from the grains of this crop. Therefore, there is a need to refine the distillation process to make it more profitable as a small scale industry in the region. As tourism is increasing in the region the demand for this locally made *chhung*/beer will be more. Apart from this, barley seeds are roasted and ground into powder called *tsampa*, the main staple food of Ladakhis.

Herbal Farming

The Himalayan region is the centre of origin of most of the plants commonly used in the traditional systems of herbal medicine. The most commonly practiced traditional medicine of Indian cold desert is Tibetian system of medicine called as *Amchi* (*Sowa rigpa*) and the practitioners of this medicine are called *Amchis* (Superior of all). Use of medicinal plants along with minerals and animal products in traditional knowledge is still in common practice in most of the areas of cold arid region. It has been the only health care facility available to the people of Ladakh and other cold arid regions of Himalaya till recent times. Even the allopathic medicine introduced with Government support in the region could not replace *Amchi* medicine in many parts of these regions due to its effectiveness, strong socio-cultural and religious background (Chaurasia *et al*., 2008).

Kumar *et al*. (2009b) enlisted number of ethno-medicinal plants from Nubra valley which had medicinal properties against kidney complaints, curing cold and cough, treating fever and curing respiratory problems like asthma and bronchitis, etc. Economically viable and highly demanded medicinal herbs include *Aconitum heterophyllum, Arnebia euchroma, Artemisia mertima, Dactylorrhiza hatagirea, Hyocymus niger, Inula racemosa, Picrorhiza kurrooa, Rheum* spp., *Sassurea costus* and *Ephedra gerardiana*. Lamo *et al*. (2012) reported twenty eight important plant species used for culinary purpose and curing number diseases by the inhabitants of the region (Table 1). Utilization of ethno-medicinal properties of various underutilized herbs has been reported by Ballabh and Chaurasia (2011).

Over-exploitation of many of these medicinal plants has led to their inclusion in the list of rare, endangered and threatened category. For conservation, income and employment generation these medicinal plants should

Table 1. Some important herbal plants of cold arid region and their uses

Plants	Parts and Uses
Allium prezewalskianum	Leaf decoction-stomach complaints
Cariun carvi	Anthelmintic, carminative, stimulant and stomachic and tonic
Agaricus campestris	Constipation
Saussurea gossypiphora	Root paste applied on cuts and bruises
Arnebia euchroma	Leaf is used against cough and improves hair growth
Lepidium latifolium	Against rheumatism and antibacterial
Capparis spinosa	Hyperacidity
Rhodiola heterodonta	Anti-stress, restores memory and health tonic
Mentha longifolia	Headache and stomachache
Oxyria digyna	Digestive and purgative
Potentilla atrosanguinea	Leaf paste used against stomachache, cough cold, sore throat and ulcer. Seed paste applied on face as UV protectant
Taraxacum officinale	Used as tonic, blood purifier, against bowel complaints and kidney disorders
Thymus serpullum	Carminative, expectorant and stimulant
Urtica hyperborea	Against rheumatism
Chenopodium botrys	Anthelmintic, laxative and against stomach complaints

be diversified into existing cropping and agroforestry systems. Most of these species can be easily intercropped with local tree species, being native to this region. Tree spacing and management systems need to be fine-tuned as per the intercropped medicinal plant (Butola *et al*., 2012). This would require strong government support policy and planning with established markets, processing, packaging, and transportation and value addition.

Fodder Production and Conservation

Fodder resource development is an important component for the promotion and production of livestock in cold arid region. Alfalfa (*Medicago falcata*) is one of the major perennial fodder crops grown in all type of soil conditions at different altitudes in cold arid region. It is nutritious and all kind of animals grazes it. This is grown on field bunds, channel bunds,

Fig. 5. Alfalfa (Medicago falcata) growing on field bunds, fields and under horti-pastoral system and dried hay stored on the roof tops and hill slopes.

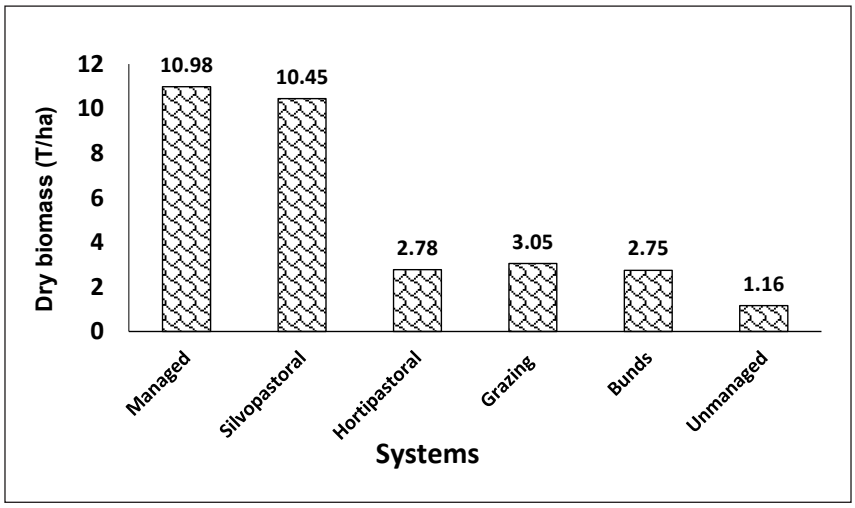

Fig. 6. Dry biomass (t/ha) production of alfalfa under different systems of cultivation.

sole crops for fodder and seed production, under silvi- and hoti-pastoral systems (Fig. 5). This crop is harvested during its maximum growth, producing sufficient biomass (Fig. 6). It is conserved as hay to meet the fodder demand during winter. The hay is dried and stored on the roof of the houses and other structures (Fig. 5). During extreme cold this hay is transported to the upper altitudes for horses, yak, pashmina goats and other animals. Indian Army also purchases it from local people for their horses.

The other sources of fodder are crops residues, indigenous grasses, legumes, and trees (salix and populus), etc. Covered barley (*Hordeum winlense*) and black pea (*Pisum arvense*) are grown mainly as fodder crops. Cover barley and wheat residues are mixed with meadow hay for livestock stall feeding in winter. Better rangeland management and development should also be taken for sustainable production. Large number of palatable plant species grow in Changthang and other grazing lands. *Astragalus, Artemisia, Agropyron, Festuca, Orzopris, Lolium* and *Stipa. Chenopodia* and *Eurotia ceratoides* are the common shrubs in the area having multiple uses.

Introduction of suitable fodder crops varieties is urgently required to meet out the fodder demand in the region. Varieties of fodder crops, like, oat, maize, barley, pea and cowpea should be tested to promote the fodder cultivation in the region. Although, oat cv. kent is grown in large scale but there are more promising varieties of oats are available. RRS, CAZRI, Leh introduced JHO 822, JHO 851 and JHO 2004 with the participation of IGFRI, Jhansi.

Fodder production can be promoted in cold arid region by following ways:

i. Collection and evaluation of promising species of fodder in the region.

ii. Introduction of improved varieties of cultivated forages, grasses and legumes.

iii. Quality seed production of selected crop species/varieties at farmers' field to assure seed availability.

iv. Management of pasture lands for sustainable production.

v. Development of mixed fodder blocks and improved techniques for fodder conservation and utilization.

vi. Capacity building of farmers, trainings and linkages with other organisations.

Livestock Production and Management

Animals are an important component of Ladakhi subsistence agriculture. They raise cattle, sheep, goats, horses and Dzo (cross between yak and cow), which is their primary source of milk, meat, wool and other byproducts. Cattle are small in size with low milk yield but yak and goats are also reared for milking in the extreme cold areas. Mostly sheep and goats are reared for wool, milk and meat purpose. The high mountain pasture lands are maintained as grazing areas for yaks, sheep and goats. Goat and sheep dominated the

Fig. 7. Changthangi breed of Pashmina goat and yak in the Changthang region.

livestock production system in the cold arid region. Goats are considered as poor man's cow (Butola *et al*., 2012). Pashmina goat, being native to the Himalayas, is well acclimatized to the high altitudes and cold climate of Ladakh, Changthang or Baltistan (Kashmir region) and neighboring areas of Tibet. The Changthangi breed (Fig. 7) found in the Changthang region yields 200 to 250 g of fine grade Pashmina annually. The population of this breed is decreasing because of degradation of pasture lands. As compared to others, pashmina goat is most profitable as it is reared mostly for pashmina wool which fetches a handsome price in both national and international markets. Sheep is also equally important small ruminant reared for wool, meat and FYM. It yields fine carpet type wool which is used locally to prepare famous Ladakhi carpets, woolen clothes and need based items for house hold.

Yak is another important animal for the rural inhabitants of extreme cold region providing milk, meat, fibre, skin and hide (Fig. 7). Yak is considered as a lifeline for the high landers. It is an excellent pack and transport animal in snow bound passes which can carry heavy loads. Male yak hybrids known as Dzo, are used for ploughing and draught power under the xeric environment. The female hybrid (dzomo) yields more milk than demo or local cows. Yak rearing is still considered a noble profession by Buddhists living for centuries with ancient history and culture.

Livestock-mixed farming system in the cold arid regions plays a significant role in livelihood sustainability. Considering food security issues, it is appropriate to manage mixed livestock for increasing animal productivity for the overall social benefits of this sector (Baba *et al*., 2011). Therefore there is need to give due attention and support to promote livestock in cold arid region.

Fish farming

Cold water fish production can be one of the additional sources of income generation in the region. Looking into the scope of fish market in the region, ICAR-Directorate of Coldwater Fisheries Research, Bhimtal initiated highland trout farming at Chushout Shamma village of Chushout block, Leh near the bank of Indus river at 3280 meter above sea level which is a perennial source of water. The seed of rainbow trout was distributed to the farmers for the first time.

Art and Craft

In Ladakh variety of handmade articles are produced by the local artisans on their own devices for self-uses and also for marketing. The Changpa women weave textiles for use as clothes, blankets, containers for food, bags, covering for floors, tent walls, and saddles. The women also weave woolen fabric *snambu* combining lamb and sheep wool for making garments. The men weave blankets, saddlebags and tents. They weave blankets of goat and

yak hair, which are very warm, and help the shepherds in meeting the harsh climatic conditions.

The pashmina wool is either directly sold to the traders and/or variety of items are produced from this particularly the shawls. Export quality shawls are also produced. As tourism in these areas is increasing, therefore, the demand of handicraft items and antics is increasing. This requires value addition and marketing network for promoting the handicraft industry at small scale as additional source of income in the region. This will open new avenues of employment generation particularly through integration of multi enterprises in the system.

Ecotourism

Tourism has now emerged as one of the dominant source of employment generation and economy in the region. The Ladakh's landscape and unique cultural heritage have been the major attractions since it was opened to tourists in 1974. Number of tourists visiting Ladakh has increased considerably from 527 in 1974 to over 25,000 tourists in 2005 and has crossed more than one lakh tourists during 2013 and14. Apart from the foreign tourists Indian tourist are also visiting the region. Most of the tourists visit during June to September even upto mid of October for a variety of activities including trekking, rafting and sightseeing. Despite large numbers of tourists are visiting Ladakh every year, the tourism industry remains largely untapped. One of the main reasons for this sector is lack of good infrastructure. If tapped properly, this can transform Ladakh region. In this regard, the provision of roads is an especially urgent concern, as is the setting up of facilities like telecommunication, medical help and emergency evacuation services. There is also a great requirement to set up an institute for professionally training locals in hospitality management. Instead to consider it as simple tourism, it should be emphasized as ecotourism considering the landscape, geomorphological structure of hills and slopes, high altitude mountains, inner pasture lands water bodies, variety of flora and fauna and century old Ladakhi culture. This requires an institutional support to promote such activities in the region. Effective implementation of these models in the region will help in social, economic and environmental development. However, at the same time there is need to preserve the environment and Ladakh's traditional values and culture as well (Ladakh - Vision document 2025).

Futuristic Remarks

Multi-enterprise options will strengthen the socio-economic status of the people in this region. Promotion of integrated farming systems and crop diversification in traditional agroforestry system; horticultural and vegetable production using scientific methodology, protected cultivation, organic and herbal farming, and value addition to the produce will help Ladakhis to ensure sustainable livelihood during peak winter months when the region is cut off from the rest of the world. In addition, infrastructural support to promote offseason vegetable production, seed production, storage, transport facility and marketing network; organized small scale industry for pashmina wool and other handicraft items and use of solar energy for agro-processing will ensure socio-economic upliftment of the farmers in the region. Improved technologies for livestock production and management (dairy and goat farming), in situ conservation of indigenous genetic resources and protection of traditional varieties involving the farming communities and institutional support to improve the scope of ecotourism and small scale industries are additional avenues to ensure sustainable livelihood, better socio-economic status and employment generation for the cold arid region of India.

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