Chapter Five
Productivity Increasing Technologies

Introduction

The inhabitants of the HKH region inherit strong livestock traditions along with subsistence level crop cultivation. While maintaining this socioeconomic profile over centuries, the traditional approaches have undergone a process of transformation. Better communication with the rest of the world, and easy access to neighbouring commercial markets have motivated the tradition bound dwellers to shift to high-value farm operations. Although the shift is slow and gradual, mainly due to poor resources, it is nevertheless visible. The cropping approach is now based on cash crop farming and inter-systemic linkages, new forms of activities, and increased flow of inputs from science and technology (Partap 1996). Due to physiographic constraints, and fragmentation of permanent land holdings within the family, scope for expanding cultivation on a larger scale used to be limited. Finally, the number of marginal and small farmers is increasing throughout the HKH region. Incidentally, the situation has challenged small farmers to integrate scarce resources to such an extent that farm productivity is optimum (Partap 1996).

There is evidence that fruit and vegetable production is emerging as the most significant means of cash generation, although still heavily integrated with livestock production. New technological choices such as off-season vegetable and fruit production, cultivation, the harvesting of medicinal plants, floriculture, and improved varieties of major crops have encouraged the small mountain farmer to accept the challenge and work with the changing socioeconomic scenario.

This chapter contains various technologies for improving the productivity of the orchard, for growing vegetables and other cash crops, and for better animal husbandry. This technology package also includes successful indigenous practices, which may be blended with modern innovations to make them culturally and environmentally friendly within a particular farming zone. Some options also focus on farm mechanisation, necessary for farming in particular agro-ecological conditions.

Katcha Orchards

Significance

The apple orchard is the most successful and popular proposition for a mountain farmer in Balochistan, subject to water availability. However, a new apple orchard takes a minimum of five to seven years to generate cash flow. Meanwhile, it involves considerable investment to become established and to reach the fruiting stage.

Plate 27: **Prune, Plum etc Planted among Apple Trees**

Katcha trees have changed the economic scenario for orchard growers. This technology has emerged as a popular one among local farmers, especially since it generates early income during the interim period before a permanent orchard reaches optimum yield, and afterwards provides the option of inter-cropping.

Farmers lack resources and their farm revenues must be supplemented by some other source of income to support their poor economy in the meantime.

Katcha means 'temporary'. This orchard technology has given relief to local apple growers. Fast growing *katcha* fruit trees start bearing fruit within two to three years providing a means of income generation at the farm. Due to their shorter lifespan, they complete their growth cycle within half a decade, at the time a permanent orchard (i.e., mostly of apples) reaches peak production.

Components

A *katcha* orchard is temporarily established for a maximum period of 6 to 8 years. Apples, apricots and almonds are considered permanent orchard trees because their productive lifespan is longer. The permanent orchard tree takes no less than five to seven years to yield the desired level of productivity. Meanwhile, the temporary (*katcha*) fruit trees are planted among the permanent trees.

For this purpose, parallel rows of rapidly growing *katcha* fruit trees (i.e., mostly peaches and plums) are established in between permanent tree rows. This practice demands a slight increase in the distance, plant to plant (i.e., 10 x 10m), between the permanent trees. The *katcha* trees start producing fruit during the second or third year of plantation and are uprooted after six to eight years when permanent orchards reach the stage of optimum yield. Their removal follows inter-cropping of alfalfa and other vegetable crops by farmers. Farmers may make money by selling the wood of uprooted trees or they may use it for domestic needs.

Plate 28: ***Modern Pruning Techniques Help Improve Orchard Productivity***

In Balochistan, orchard producers apply rarely used modern pruning techniques, consequently, many taller trees are seen. The productivity per tree can easily be increased manifold by training farmers in modern pruning techniques.

Pruning Techniques

Significance

The pruning of apple fruit trees is the foremost indigenous practice for the maintenance of tree vigour and productivity. Low yields and poor fruit quality may be attributed to poor light penetration in the tree canopy. Alternate bearing, poor fruit set, high insect-pest and disease incidence, and poor fruit colour are also due to uncontrolled tree growth.

Components

Orchards are pruned manually, with the following basic rules being adhered to while pruning to enhance yields.

Rule 1

- Limb orientation influences fruiting. Vertical or upright vigorous growth habits do not induce lateral branching so that there is no flower bud formation and consequently no fruit will be formed on such branches of a tree.
- Limbs at a 30 to 45 degree angle develop not only laterals but some spurs that lead to early flower bud formation.
- Limbs below horizontal orientation develop water shoots and less fruit of poor quality.

Rule 2

- Unpruned limbs do not develop proper laterals and spurs. The lower part of the limbs also remain barren.
- Severe pruning results in heavy regrowth that does not favour bud formation.

Rule 3

- Intensity of light spectrum, essential for fruit bud formation, decreases sharply after it intercepts the tree periphery. Any inner part receiving less than 30 per cent sunshine cannot develop flower buds.

Rule 4

- The best time for bending branches is when growth is about to cease, i.e. in early August for cooler regions and in the first half of September for relatively less cold areas.

Smoking of Orchards

Significance

During winter, when temperatures go down to well below freezing (i.e. -12°C), orchards are highly prone to frost and severe chill injuries that may cause high mortality in trees. Irrigation for saving trees is not possible owing to the very low temperatures. If farmers do not take appropriate measures to protect trees from severe cold, it may devastate their orchards. Damage is particularly heavy when trees are at the flowering and sprouting stage. Smoking of orchards has emerged as an orchard saving technology in the highlands of Balochistan. It is the cheapest and easiest way of saving trees from frost injury.

Components

During the coldest nights, when there is the danger of damage by frost or by severe, chilling, windy weather, local farmers create smoke by burning bags, leaves, debris etc. in their orchards. Smoke is set in the direction of the wind so that it reaches all around the orchard. The smoke warms up the micro-climate and eventually the trees are protected. This technology has been widely adopted by local farmers.

Orchard Bathing

Significance

Due to low rainfall and a dry climate, the apple orchards are exposed to dust and

Plate 29: ***Smoking of Orchards Protects Fruit Trees from Frost Injury***

Plate 30: ***Orchard Bathing Saves Fruit Trees from Dust and Pests in the Absence of Rainfall***

pest infestation. The deposition of dust on apple fruit results in low production and fruit of inferior quality, which ultimately reduces farm income. Apple orchards are given a 'bath' to overcome this problem. Farmers believe that, in this way, the colour of fruit is also improved and it fetches a better market price.

Components

Rain is the main way in which orchards are washed (particularly apple trees). Rain-baths eliminate losses by dust and pests during fall and winter. Whenever rain is delayed, farmers use an indigenous and local method of orchard bathing. Using a long rubber pipe, along with a powerful spray nozzle, for washing trees, the farmer connects the pipe to a water source, i.e., a water tank or water channel. A mobile water tank behind a tractor is becoming a popular method of supplying water for orchard bathing. A spray nozzle operates through the tractor. Water is showered on to the trees using a long pipe or by moving the water tank closer to the trees. This technology is in common use nowadays, mainly to prevent loss due to pests and to allow farmers to market quality produce.

Wire Nets for Vines

Significance

Grape production is common in northern Balochistan. Traditionally, vines were grown on trees, ridges, etc. Wire net technology allows more space for the vines to grow with a relatively high density per unit of land which improves grape yields. Unlike traditional methods of grape production, farmers are able to inter-crop berseem, lucerne, etc with grapevines, which further increases farm income.

Traditional grape production methods have two main disadvantages:

- heavy losses throug predators such as birds and animals, and

Plate 31: ***Grape Production under Wire Nets***

Wire nets are gaining popularity with farmers for growing grape vines. However, because the bunches of grapes are always in the shade, they have the greenish appearance of having been prematurely harvested. The market agent grades the produce as low quality and prices it accordingly. Research work is required to eliminate the myth that grapes grown in this way are of inferior quality.

- a laborious and difficult harvest of produce.

This technology has been developed mainly to overcome these two problems in addition to the other benefits it confers.

Components

Vines are grown in fields by following a row to row and plant to plant layout. Overhead wire nets are installed all over the field with the support of wooden or iron poles. Initially, young vines are directed towards the wire net to grow freely. Usually, they attain a height of about 1.5 to 2.5m above the ground. Farmers do follow plant to plant and row to row distancing (i.e., 3 x 3m and 3 x 3m) and it is always sufficiently wide enough to allow inter-cropping, mostly of fodder crops such as *alfalfa*. Bunches of grapes hanging under the cover of wire nets and mother vines are protected from birds. They remain clean and protected from other pests. This method allows quick and easy harvesting while walking between the rows under the net.

Trellis Grape Production

Significance

Traditional grape production on ridges causes heavy losses in terms of low grape yield. Additionally, the traditional system is labour-intensive, particularly in the beginning. It also relies on heavy water supplies and eventually incurs higher water losses.

The Department of Agriculture, Balochistan, has successfully introduced

Plate 32: ***Trellis Grape Production System***

The Trellis System has potential for improving grape yields. Organized and wide-scale extension efforts are required to introduce it amongst grape producers.

an improved grape production technology during the past decade called the Trellis System of grape production. It replaces the traditional production of grapes on ridges. It improves grape yields substantially by preventing field losses, and the produce is uniform. This technology has been cleverly combined with trickle irrigation. This combination of two modern technologies has encouraged farmers to open more areas for grape vines previously never suited to this purpose.

Components

In a selected field, angle irons (poles) are erected according to a field layout. A standard layout is followed, i.e., having a 6m distance between poles and a row to row distance of about 4.5m. An angle iron approximately 1.5m long with a 0.9m T-arm on one end is used for this purpose. Each pole is erected in such a way that it is 0.3m inside the ground with the T-arm about 1.2m above the ground. Each pole in the row is connected to the next by trellises. The T-arm of each angle iron possesses 0.3m spaced holes, and these allow the stretching of parallel metallic wires of a certain gauge from one end of the row to the other while connecting all T-arms of the pole with each other.

Vines are planted along the row, 2.5m apart. Young vines are trained to climb on trellises. This allows the vines to grow above the ground and prevents many diseases. It also facilitates a quick and easy harvest.

Indigenous Greenhouse Conditions for Grapevines

Significance

Farmers of Nubra Valley in the western Himalayas of Indian territory grow grapes under severe, cold desert conditions by

Plate 33: ***Indigenous Greenhouse in Ladakh Area***

creating a warmer micro-climate. The localised greenhouse conditions have made it possible for local farmers to undertake grape cultivation.

Components

Warmer niches are located for grape cultivation. Vines are grown in pits by regulating the temperature of the basins. Pits are filled with locally available crushed stone, bricks, grass, hay, and soil. This warms up the micro-climate of the basin, which is otherwise cool due to the sandy soil. The vines are also covered with warm clothes, gunny bags, or wooden baskets for protection against the cold during the first one to two years.

Modern Nursery Techniques

Significance

Non-availability of true variety saplings for direct plantation is a critical constraint in mountainous areas. The root stocks of different fruit species such as apples, cherries, etc are imported by spending foreign exchange. This root stock is later used for propagating certain varieties using budding and grafting techniques. Budding is commonly used in Balochistan, however, it takes longer (two years) to develop a true variety plant than when by using grafting technique, in which case it takes only one year. Both these techniques are an important means of renovating old and unproductive orchards. They are also useful for changing the variety of trees in the orchard, a need brought about by the following factors.

- A decrease in market demand for certain varieties and loss of commercial value.
- Top working has a significant dwarfing effect.
- Varieties planted earlier may not cross-pollinate properly.

Hot bed technology is a revolution in nursery techniques. It may eliminate all root stock imports and subsequent budding or grafting procedures. This technique pro-

vides directly true variety saplings for field plantation. In this way, it cuts one to two years off the growing time of the vines for the benefit of farmer or nursery grower, thereby reducing expenses considerably.

Components

To carry out top working of trees and to propagate the germplasm, the following three options are available.

- Grafting
- Budding
- Hot bed sapling production

Grafting

Grafting is done with dormant scion wood with two buds in April to May, when the bark of a top-worked tree separates easily from the wood. Scion woods for grafting must be collected in the dormant season and kept dormant in cold storage in plastic bags until use. The best time to head back trees is February to March.

A good scion wood must have the following properties.

- Must have shown one year's growth of 0.3 to 0.6m during the previous season.
- Should be as thick as a lead pencil.
- Must have large, visible buds.
- Should be free of injury, infection, and remain absolutely dormant.

There are two types of grafting, that is cleft grafting and bark grafting.

Cleft grafting: This is the most commonly used method. It is important to consider the following while carrying out cleft grafting.

- The best branches to graft are below six inches and should be upright or sloped, at an angle of not less than 45°.
- The scions and stocks must be inserted carefully and tightly.
- A strip of plastic tape should be tied around the stock and left for about three months, after this time it must be cut but not removed.
- All cut surfaces should be sealed with grafting wax, asphalt paint, or non-toxic oil paint.

Bark grafting: Bark grafting is easier to carry out than cleft grafting. It gives good results in the case of stone fruits and pears. The disadvantage is that the graft is sensitive to wind damage.

Budding

Budding must be carried out in late summer or early fall, using bud-sticks. It is commonly used for top working of peaches, plums, cherries, and apples. The following rules should be followed while carrying out budding.

- Head back stock trees, as described earlier under the section on grafting.
- During summer time, select 3 to 5 new shoots for autumn budding.
- One-year old shoots are ready in autumn for T-budding.

Great care must be taken of the grafts in the first few years, mainly for the following reasons.

- The new fast-growing shoots are sensitive to breakage by wind, as well as damage by insects and fungal disease.
- So that a good, strong branch structure of the new top is developed.

During the summer time, inspect the grafts weekly and carry out the following operations.

- Tighten them when they reach 15 to 20 cm in thickness to prevent wind damage.
- Pay careful attention to plant protection measures.
- Carry out summer pruning, pinching, and bending of new secondary shoots, to form a proper tree branch system.

Hot bed sapling production

This is an innovation for producing true variety saplings or root stock in a very short duration to meet the demand of large scale orchard plantations. The main constraint with this technology is that it requires a stable source of electricity round the clock. Other requirements include a suitable room for controlling climate, a small specified electricity transformer, and specified electrical heating elements.

A small sandy bed (15cm depth) or a series of sandy beds (each measuring roughly 1 to 2m) are constructed in a room.

Electrical elements are used to maintain the sub-surface temperature of the sandy bed within a range of 20 to 24°C by placing them under the surface according to a layout. These elements are connected with an electricity supply through a transformer.

A standard bed measuring 1m to 2m may contain about 6,000 cuttings to produce saplings. One end of the cutting is treated with a solution of Indwell Butyric Acid (IBA) and is placed vertically into the bed. The moisture of the bed is maintained at field capacity, and the humidity of the room should be at 80 per cent.

Root initiation takes place within four to six weeks. Afterwards, the cutting is transplanted into a nursery tunnel or open soil beds.

Commercialised Wild Orchards

Significance

Low-producing orchards of wild fruit trees such as apricots, walnuts, crab apples, almonds, *behmi* (wild apricot), and grapes are a common sight in Ladakh and other areas of the western Indian Himalayas. Wild plantations are being converted into commercial orchards using modern nursery techniques and improved varieties, as introduced by Parmer University. Eventually, the Kinnaur apple emerged as the most prized crop, fetching maximum prices in the market due to its high quality and delayed marketing season. Apricots, walnuts, and almonds cultivation is also becoming a valuable commercial enterprise.

Components

Modern grafting techniques are being used extensively to convert wild orchards into a highly productive commercial enterprise.

Plate 34: ***Hotbed Technology is Feasible for Commercial and Community Level Multiplication of Root Stocks and True Variety Saplings of Orchard Plants***

Wild walnut trees are grafted with improved high-yielding varieties producing thin-shelled dry fruit.

Simultaneously, the improvement of wild apricot plants by introducing modern varieties is progressing quickly in different valleys. Scions of sweet fruit varieties are grafted on to wild apricot plants. Local people are now skilled enough to insert half lamina along with petiole into a peeled part of the wild stock. The union is tied with bark. Preferably, two- to three-year old scions are used. The whole procedure involves cutting bark at a bud point of a selected plant with slow rotary movements, in such a manner that a cylindrical bark cap is peeled off from the top of the stem. After grafting with a scion, this bark cap is placed back over the top and is sufficiently tightened, so that the union of the scion's petiole with the stock is strengthened. The use of the peeled off bark cap signifies the local wisdom for ensuring enough moisture reaches the grafted union. The half lamina is used as a check against any possible damage to the union due to wind.

Fresh-growing trunks and young plants are wrapped with gunny bags or covered by a tin sheet to protect them from browsing goats.

Off-season Vegetable Production

Significance

Vegetable production in cold mountain deserts has traditionally been limited to the domestic scene. In recent years, development of infrastructure resulting from the tourism industry, etc has created more demand and better marketing opportunities for locally produced vegetables. Vegetable production promises a consistent cash flow during most of the year. Finally, the cropping pattern in cold deserts has undergone a tremendous change with the introduction of off-season vegetable crops;

Plate 35: ***Off-season Vegetable Production Can Increase the Income of a Mountain Farmer Substantially***

women are heavily involved in the local sale of produce.

Components

Vegetable cultivation, particularly, has a great potential for improving income generation in the cold deserts of Ladakh and Himachal Pradesh. In the Ladakh area, cabbages, cauliflowers, turnip, *knolkhal* (Brassica), Chinese radishes, carrots, spinach, *methi*, coriander, and potatoes are being grown successfully. In addition to local sales, these vegetables are marketed in neighbouring lowland areas as off-season vegetables and fetch good prices. Cauliflowers are especially produced as an off-season vegetable during July through to the end of September.

Ladakhi farmers follow an indigenous root-spreading technique for increasing vegetable production. A wooden implement called a '*tokhre*' is used for this purpose. They use *tokhre*(s) for digging soil around vegetable plants to redirect roots towards the surface of the soil. The objective is to enable the plant to obtain maximum nutrients from the fertile topsoil. The wooden structure protects roots from any mechanical damage and is also used for weeding.

Peas, seed potatoes, cauliflowers, cabbages, turnip, and coriander are important vegetables grown in Himachal Pradesh. Seed potatoes and peas cover most of the cropped area in Lahaul. Government subsidies and incentives have a positive impact on adapting vegetable cultivation to produce cash crops.

The cold desert areas are designated disease-free zones. The cold climate is very suitable for vegetable seed production. Cabbage and cauliflower seed production is known as a successful economic enterprise in this region. Seed potato cultivation for one of the biggest success stories for modern technology. The Lahaul Potato Growers Cooperative Society has emerged as a leader in the history of co-operative movements in India. The millet and coarse grain-based farming system has changed to extensive seed potato cultivation. This

region has witnessed the highest yield level in the world. Peas are also making their mark, even in zones where the seed potato dominates. Four harvests are completed in order to enter the markets of the plains selling off-season vegetables. Farmers normally receive three to four times more than normal market prices from businessmen who visit and contact the farmers directly.

Indigenous Farm Resource Management

Significance

Cold deserts face formidable challenges in terms of their remoteness, the fragility of their resources, and their inhospitable climates. The inhabitants have explored the interactions of biotic and abiotic components of their local ecosystem to an impressive degree. Farming methods are based on the indigenous knowledge and practices of the people of the region. Cropping patterns have been adjusted as per their food needs, availability of resources, sloping terrain, and altitudinal zonation of land holdings. Their farming practices and resource management are synonymous with traditional knowledge and maintain a delicate balance between sociocultural ethos and specific qualities of the region. Indigenous knowledge remains extremely valuable in terms of its wider applicability, adoption, and uniqueness.

Components

Crop production

Some of the indigenous farm management practices that prevail in the cold deserts of Ladakh and HP are discussed here in relevance to the sustainable use of farm resources.

In the absence of a modern solar calendar for the region, Ladakhi farmers have developed their own astrological system encompassing solar observation, astrological dogma, and traditional wisdom of observing the previous seasons. Agro-meteorological forecasts are made in order to predict the advent of snowfall, winds, storms, solar radiation, and pests. A special cairn is built on the eastern side of a field and the field is ploughed along the skyline ridge. During spring, once the northerly progression of the sunrise reaches this point, it is taken as a favourable omen for cultivating various crops, with a high probability of suitable weather.

Annual crop rotation in some areas makes optimum use of local agro-climatic conditions. In Pattan Valley, the farmers take advantage of a slightly lower elevation and relatively longer summer to grow two crops in one season. Since fields are covered until the end of April, farmers spread soil over snow in fields to catalyse snow melt. This practice enables them to start land preparation and sowing of the barley crop in March and early April. Barley is harvested in July and is immediately followed by the sowing of buckwheat. Buckwheat is harvested by the end of September. *Kuth* is preferably sown in November prior to any snowfall, since a longer period of seed stratification is essential for good germination. The *kuth* crop is harvested after mid-August. In any climatic zone, the order of crop rotation follows crop maturity seasons. The most prevalent sequence is wheat, barley, peas, and buckwheat. However, barley-peas-wheat is also a common rotation. Mixed cropping is also a common practice for maintaining soil fertility and as security against single crop failure. The cultivation of maize in combination with millet, beans, and lentils is a general mixed cropping pattern.

In some locations, crop rotation is governed by soil fertility. For example, since a barley crop requires heavy doses of organic manure for a good yield, the farmer will thoroughly manure one third of the land holding, depending upon the quantity of available manure, and grow barley in the first year. This part of the field is then used for growing buckwheat during the next year, with no additional input of manure. Wheat is grown in the third year. Meanwhile, another one-third of the landholding is prepared for a similar crop rotation. Under irrigated conditions, wheat alternates with paddy. Mono cropping is generally practised under rainfall conditions. Wheat or barley rotates with maize and/or lentils. The local crop rotation practices also take into consideration the control of any soil-borne or crop-residue carrying diseases and pests.

Local germplasms of major crops are highly acclimatised to the peculiar harsh, dry, and cold climates as well as the short growing period. The conservation and propagation of local germplasm receives high priority from local farmers.

Local germplasm is conserved year after year. Table 20 indicates the traditional germplasms Ladakh. Some studies conducted by Sher-e-Kashmir University of Agricultural Sciences and Technology and the Research Station at Leh have indicated higher yields of some of the local varieties compared to the recommended modern varieties from the adjoining plains.

The common practice is to collect seed from selected stands that are showing vigour, disease resistance, and higher productivity for the future. After every three to four years, the seed source is changed without diluting selection criterion. It extends a natural check against inbreeding and low productivity.

Farmers have developed simple and unique methods for different farm operations to increase productivity. A stone called *shangma*, light bluish in colour, is used for seed control. A small heap of soil is piled up in the middle of a fallow field in the month of December. Pieces of soluble *shangma* stone are spread over it. Mild irrigation or rainfall creates a thin layer of it all over the field.

It successfully inhibits plant growth in the field for from 10 to 15 days. The practice

Table 20: Traditional Germplasm in Ladakh

Crops	Variety of crops (Phonetic)	Transliteration	Meaning
Barley	Ne-nak (Ladd, nak-nas)	-	Black barley
			Heavy barley
	Yang-ma	Gyong-ma	Early ripening
	Yang-kar	Eyeing-dkar	White wealth
	Sermo	-	Yellow mother
	Tug-zur	Drug-zur	Six cornered
Wheat	To-chen	Gro-chen	Big wheat
	To-chen	Gro-chund	Small wheat
Peas	Sren-mar	Sran-mar	-
Alfalfa	Buck-suk	-	-
Lucerne	(Lad-Lol)	-	-
Mustard	Nyus-Kara	Yungs-dkar	-
Buckwheat	Ta-wo	Bro-wo	-

Plate 36: **A Chinese Woman Broadcasting Seed**

may be shifted according to the cultivation schedule.

Coriander seeds are hammered with leather shoes, which improves germination – probably because the hard testa of the seed is broken during this process of mild mechanical stratification.

Monastic traditions are employed for improving barley yields. Whenever the barley yield goes down and most seeds are empty, farmers will spread sand sanctified by the Lamas all over the fields. This seems to be a soil management practice that improves the porosity of soils when the inner layers become compact due to continuous barley cultivation. Somehow the practice has been linked to religious faith.

Unloading 20 to 25kg of manure after every seven steps taken by a woman ensures soil fertility and uniform distribution of organic manure. Later, the remainder is scattered all over the field. It has been observed that this method gives optimum manure distribution over a particular area.

Crop sowing is mostly undertaken by young girls who broadcast the seed. Girls are trained during childhood to pick up uniform handfuls of seed. One handful is broadcasted in three to four equal lots. The quantity of each lot is determined by whether the ploughing will be narrow or wide. Proper seed rate and uniform spacing is verified by random placing of the palm in the field from which a handful of soil is gathered. Each time, a handful should contain seven seeds. It coincides roughly with the recommended seed rates.

Strings of yak hair are used to check grain loss by birds from mature crops. These strings are used for shooting or harassing birds visiting fields by catapulting small stones from a distance.

Animals, particularly *dzo*(s), are trained to thresh the harvest by trampling. A large circle of packed earth (i.e., about 10m in diameter) forms the threshing floor. The animals are tied in line to a central pole. *Dzo*(s), once stirred, will revolve continuously for hours without any fatigue. There is often a combination of animals (as many

as twelve) with *dzo*(s) in the inner circle. A container is used for collecting animal dung during the operation to prevent any spoilage of the grain by excreta.

Special wooden houses away from residential units are constructed for grain storage. Sufficient care is taken to check the entry of rodents. Well- ventilated conventional stores ensure grain storage for considerably long periods in case of drought or famine.

Farming communities have developed different kinds of socioculturally bonded community organizations to carry out routine farm operations on a sustainable basis. These organizations also come forward to handle the situation in case of any calamity. Some of these organizations are described below.

In most villages, a village mate is annually selected from certain families and his special job is to make all kinds of community related announcements, such as the necessity of repairing the *kuhl*(s) and water tanks, as well as any special events, ceremonies, and so on. This man walks through the streets and shouts out the message. A token amount of money is collected and paid to him.

Animal production

Indigenous practices such as breeding, health care, and feeding to improve the productivity of native livestock are discussed below (Table 21).

Although sheep and goats are pastoral wealth, *dzo/dzomo*, yak/*demo*, and donkeys are choice animals in most areas, due to the physiograghic features of the region, and serve as the main source of draught power. Sometimes, even sheep and goats are used for transporting goods to difficult and inaccessible terrain. The cows, *dzo* and *demo*, are prinicpal milk producers for domestic consumption. Animal production is an important component of farming due to the vast amount of pastureland in the alpine zone (Table 22).

Table 21: Local Groups Sharing Responsibilities of Livestock Breeding

Organisation	Objective
Faspoon	A group of 7 to 8 families who look after indoor work in case of death
Langgsthay	Families sharing bullocks for draught purposes
Ra-rays	Collective grazing
Beyas	Group of farmers who carry out various cultivation operations together
Srang-Pa	Informer of a community

Farmers have a well-organized system for branding their animals for identification. Each family will assign a 'V' or 'U' or any shaped sign to its animals. The sign is iron branded on the outer side of the ears of the animals.

Local cattle breeds are genetically poor and, therefore, poor milch breeds. Cross-breeding of cattle with yaks is considered

Table 22: Cross Breeding of Livestock

Cross	Off spring	
	Female	Male
yak x cow	*dzomo*	*dzo*
yak x *dzomo*	*Garmo*	far or *garu* (sterile)
yak x *garmo*	*girmo*	*fir* (sterile)
yak x *girmo*	*Lokmo*	*lok* (sterile)
yak x *lokmo*	*Torgmo*	
yak x *torgmo*	*dimo*	yak

especially important to produce a strong and superior crossbreed of males called *chura*. The *chura* is small and has a heavy, thick hair coat all over the body. It is a very strong draft animal for the cold region, but it will not procreate. Selected yak bulls are maintained for crossbreeding with cows for this purpose. Breeding of cows and yaks, followed by reciprocal crosses, is an age-old practice enabling farmers to produce suitable hybrids for milk and draught power.

The animal calving/ lambing/ kidding schedule is synchronised with the warmer season in order to obtain a higher survival rate and to offer good quality forage to lactating females and growing young. The birth of farm animals takes place mostly in April and May. It is controlled either by isolating males from females during breeding seasons or by covering the male genitalia. Males of small ruminants may also be castrated.

Health management and indigenous veterinary care are very important in these areas to prevent mortality losses. Veterinary measures are quite effective for treating various animal diseases. For most problems of indisposition in cattle, the fruit of wild apricots boiled with water (called *lafe*) is given to the animal to eat. For any serious problem, a small cut in the outer portion of the animal's ear is made for the exudation of blood. In the case of dysentery, a red-hot iron is brought near the nose of an animal, this is claimed to be the most effective treatment. Most of the animal paralysis cases are treated by physiotherapy of the forehead with a warm stone, locally called *chaggar*. Common local veterinary treatments include the following.

- Long grasses found in fields are boiled and fed to animals suffering from stomach problems.
- A bottle of *sarson* (mustard) oil is fed to an animal with stomach problems.
- The bark of the *beli* tree is wrapped over the injured portion of the animal for a speedy recovery.
- The problem of falling wool in sheep is overcome by massaging in a mixture of sulphur and *sarson* oil.
- *Khurdu* disease (insect attack on sheeps' feet) is cured by wrapping the crushed leaves of the *karnu* tree on infested feet after washing with lukewarm water.
- A hot soup of *zeera* (cummin) and garlic is fed to animals suffering from simple temperatures and colds.
- Garlands of fresh garlic are hung on the necks of cows with stomach problems for effective treatment.
- Human saliva is collected after spitting it on the arm of any person and is then put into the suffering animal's eyes. This is the most effective treatment for sores affecting the eyes.
- *Jawanlari* grass, after burning with black cloth and mixing with oil, is fed to cows suffering from dysentery. This grass is dried and stored for the winter months.
- The sanctified soil of a termitorium is thrown over a cow suffering from stomach pain. The cap of any person is then beaten against the body of the

cow. A special person usually sanctifies the soil before throwing it. If such a person is not available in the village, an expert is invited from another village.

- Yaks and *dzo*(s) are prevented from drinking water after heavy work by tying their mouths. Farmers believe that allowing the yak or *dzo* to drink after intense labour leads to the formation of tumours in the neck region.

- During the lush, green, summer grazing season, animals returning from pastures are allowed restricted watering during the first twenty-four hours. They believe that the stronger urge of the animal for salt results in heavy water intake resulting in stomach inflation and subsequent death, particularly in the yak.

Special feeding practices are adopted to obtain quality produce. A native shrub, called *capsion*, is fed to sheep to increase wool production. Similarly, *pashmina* goats are grazed in deep gorges and severely cold *nallah*(s) in the upper reaches of mountains near glacial points, this is thought to give good quality mohair with longer staple length.

Dry hay is stored in open fields during September and October for the winter. It is piled up about 20 to 25cm high over a circular base made of stones. The stone base is first layered with thorny bushes. The grass bundles are then arranged over the bushes so that the top forms an ellipsoidal shape. The top is covered with rugs made from yak hair called *thobi*, followed by a layer of green, thorny bushes along with wheat straw. Finally, heavy wood logs or stones are put in place to keep it pressed down.

Common Vetch - An Important Forage Legume for Dry Mountains

Significance

Vetches originated in the Mediterranean region. Common vetch is an important plant grown throughout the world. It is used extensively as a cover crop in orchards and citrus groves for erosion control, soil improvement, green manuring, livestock forage, and wildlife food and shelter. Common vetch is a rainfed winter forage crop. Excepting for sandy soil, common vetch can be grown on all types of soil, even on depleted soil which is usually not suitable for cereal crops. It produces a reasonable bulk of forage in the cool season in the tropics, which is a time of forage deficit. It can be used as cut forage, grazed, or preserved as hay or silage.

Components

There are almost 150 vetch species reported from all over the world. *Vicia sativa* or common vetch is a semi-viny, herbaceous annual legume which grows erect in the early stages but lodges later due to a heavy mass of tendrils. Leaves are pinnately compound, with the petiole less than one cm long and hairy. Leaflets are small, entire or dentate at the apex, linear or oblong, petiolated, and are usually numerous. Flowers are crimson, purplish violet, and, rarely, white. The pods contain six to 12 seeds and shatter readily on reaching maturity. Common vetch has been found suitable for cultivation in the highlands of Balochistan, in the Sulaiman Mountains, and in the Karakoram ranges.

Common vetch does not require intensive land preparation. Two to three ploughings after harvesting the summer crop are suf-

Plate 37: ***Common Vetch in the Highlands of Balochistan***

Common vetch should be introduced into the cropping calendar of the highlands as a winter fodder crop to mitigate the nutritional stress faced by livestock, as winter is the most critical feed scarcity period.

ficient. It can be grown using the ordinary *rabi* seed drill. The line to line distance should be 30 cm and the sowing depth 5 to 8cm. An optimum seed rate of 80kg/ha gives a plant density of 120 to 150 seeds/ m^2. The best sowing season is from mid-October to mid-November. Common vetch can be intercropped with grasses, especially oats, for improvement of yield and quality. Being a legume, it can fix atmospheric nitrogen, so urea is not applied. A free living soil organism, *Rhizobium*, infects the root hair and causes formation of root nodules in the host plant, and these become sites of nitrogen fixation. *Rhizobium leguminosarum* is the vetch rhizobium and can be obtained from nodules on the roots of *Lathyrus, Pisum, Lens,* and *Vicia*. This symbiotically fixed nitrogen is not only sufficient for plant growth but also adds 80 to 100kg N per ha to the soil annually.

Maximum yield from common vetch is obtained at the stage when 50 per cent of the plant is in flower. Forage quality depletes rapidly soon after the pod filling stage. A fresh yield of 30 to 40 tons and a dry matter (DM) yield of five to eight tons/ha can be obtained, if conditions are favourable.

Vetch contains 36 per cent crude protein in the early stages and up to 26 per cent in the flowering stage. The crude fibre content is 24.3 per cent, ash 22.3 per cent, ether extract 2.8 per cent, nitrogen free extract 38.8 per cent, calcium 0.49 per cent, and phosphorous 0.61 per cent. Digestibility is 81 per cent for crude protein and 53 per cent for crude fibre. Hence, vetch makes good quality forage compared to grasses. However, the seeds cannot be fed to farm animals as they contain poisonous glycosides such as vicine.

The surplus forage can be converted into hay and silage so that it can be used during lean periods.

Urea Molasses Blocks

Significance

Small ruminants in the HKH region often face feed shortages, especially at the end of the dry season and in winter. Many animals have to survive on poor quality range plants and cereal straws, especially wheat straw. Due to the high lignin contents of these feeds, feed intake and digestibility are low. Animals often lose weight and deaths may occur from starvation. Giving supplementary feed in the form of a solid block containing molasses, urea, and other nutrients can prevent this.

Liquid molasses cannot be transported easily to rural areas and they are difficult to use in rations, being very sticky, whereas molasses in block form are easier to transport and use. Nomadic and transhumant livestock producers can carry blocks with them. Feeding molasses in block form to animals is an excellent way of regulating their intake of urea.

Components

A urea molasses block is made up as follows.

i.	molasses	50 %
ii.	urea	10 %
iii.	salt	5 %
iv.	cement (dry)	10 %
v.	wheat/rice bran	25 %

It is also possible to add more minerals to the mixture when deficiencies occur.

The making of blocks should start at the beginning of the dry season, and the blocks will then be ready for use at the end of the dry season.

Hardness of Blocks: This is essential. For large-scale use, a penerterometer is used to measure hardness.

*Plate 38: **Urea Molasses Block Being Offered to Goats***

Nutrient (i.e., energy and protein) deficiencies are prevalent in flocks. They are particularly severe during winter. A successful transfer of this technology to flock owners will boost the overall productivity of small ruminants in the mountains.

Preparation of Ingredients: All ingredients should be weighed before mixing. Molasses should not be diluted with water. Any lumps in the urea and salts should be crushed.

Mixing the Ingredients: The ingredients should be mixed by hand. The following order should be observed when adding ingredients for the best results: (a) molasses, (b) urea, (c) salt, (d) cement, (e) bran.

Half of the salt should be mixed with cement/water to improve the setting of the block. Four litres of water should be mixed with every 10kg of cement. The bran should be added gradually to ensure even distribution in the mixture.

Use of Moulds: For small moulds, buckets with a capacity of 10 litres can be used.

Big moulds can be made from four wooden boards in which slots are placed to form a rectangle. A height of 20cm is recommended. A frame of 2m x 2.5m x 0.2m can hold 1,000 litres (1,200kg) of mixture. A plastic sheet (100 microns thick) is normally placed in the mould before pouring in the mixture. Moulds should not be in direct sunlight.

Removal and Cutting: After 24 hours, the blocks are removed from the moulds. Blocks in buckets are simply turned out and the plastic removed. Marks should be made to assist in cutting a block of the required weight. For example, a mark 25 cm x 30 cm will produce a block of 10 kg if the height of the block is 20 cm. Cutting can be done with a flat spade.

Drying: The cut blocks should be placed in the shade with good ventilation. Drying time may vary according to climate and location.

The following instructions should be observed when feeding blocks to animals.

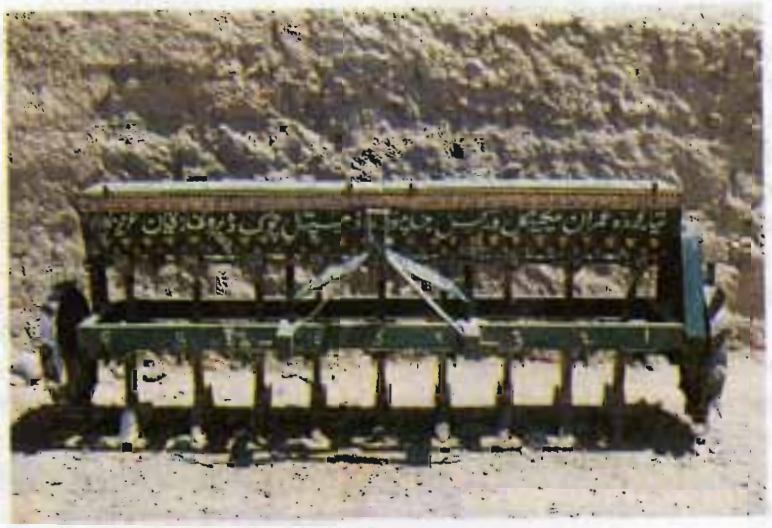
- Blocks should only be used for feeding ruminants, e.g., cattle, buffaloes, camels, sheep, and goats.
- Never feed these blocks to monogastric animals, i.e., horses, donkeys, rabbits, pigs, and chickens.
- Blocks alone must not be fed to animals. Animals must also consume enough dry feed such straw etc.
- Blocks should be given in the evening.
- Do not use blocks during the rainy season.

Modified Sowing Drill

Significance

Use of modern farm machinery has become necessary with the inflow of remunerative returns from growing high-value cash crops. The peculiar biophysical conditions of the HKH region require compatible farm machinery and implements. Unfortunately, most modern implements have been designed for agronomic practices in the plains and are not appropriate for mountain farming. The following sowing drill was invented by an employee of an agricultural research institute at Quetta, Balochistan, who happened to be a local farmer. While using an ordinary tractor-driven sowing drill, he experienced many problems due to the terrain and typical climatic constraints. He travelled to the plants where modern drills are manufactured in the Punjab, Pakistan, and was able to get a modified sowing drill made, one which meets the requirements of local agronomic practices. This drill is being used successfully in the desert area

Plate 39: ***A Prototype Modified Sowing Drill for Drop Sowing in Rainfed Mountains***



Since this drill takes into account the specific climatic, edaphic, and topographic features of arid mountains, it improves yields by achieving maximum germination and uniform stands of seedlings. By considering this machine to be a prototype model, its design can be improved and cheaper and more economical drills for arid mountains can be manufactured by involving private entrepreneurs.

of Balochistan. Neighbouring farmers prefer to use this drill on a rental basis for all their sowing operations.

Components

This drill is a modified tractor-driven sowing drill and differs from the original in the following ways.

- In desert areas where soil is relatively hard and moisture is found deeper in the soil, seeds do not reach down to the desired depth to catch moisture when sown by ordinary drills. Modified drills possess longer tillage blades supported by steel pipes which take seeds deep enough into the soil moisture.
- It works equally well under zero tillage and saves labour and the cost of two ploughings for land preparation.
- It has nine tillage blades, all of them in one line, in contrast to the two lines with alternately placed blades in the original drill.
- The original drill requires an attached land leveller behind it or post-sowing land levelling to conserve moisture. The modified drill does this job by itself because of its design, and thus saves money and labour.
- There are strong iron springs supporting the tillage blades, thus eliminating the danger of any wear and tear.

Olive Cultivation

Significance

Olive oil is considered one of the best edible oils in the world. In most of the Middle Eastern and some European countries,

Plate 40: ***Modern Olive Cultivars Possess Great Potential to be Exploited in Cold and Dry Zones of the HKH Region***

olive cultivation is very commercialised and the farmers' economy is significantly based on olive production. The countries of the HKH region import olive oil mostly for medicinal use, and the oil is very expensive. The agro-climatic conditions of the whole of the HKH belt are very favourable to olive plants. Large-scale stands of wild olive (*Olea cuspidata*) are found throughout all mountainous regions. There is great scope for introducing improved varieties of olives all over the region, which may change the socioeconomic priorities of local farmers.

Components

Seventeen improved cultivars of olive have been introduced in the hills of Uttar Pradesh, India, since 1985. These cultivars are suitable for both oil and pickling. Some of the cultivars, such as Pendolino, Leccino, Coratina, Frantoio, and Cipressino, are already performing well under local conditions on government as well as on private demonstration sites in Dehra Dun and Nainital in India. Large-scale multiplication of improved olive cultivars has been commenced using both cutting and grafting techniques. Saplings raised by grafting are planted in rainfed areas, whereas cuttings are grown under irrigated conditions (Seth 1993).

The successful cultivation of various exotic olive cultivars has taken place at a model government agricultural farm in Loralai, Balochistan, Pakistan.

Tea Cultivation

Significance

Tea, being a species of the *Camellia* genus, is a typical plant of the sub-tropical evergreen broad-leaved forest. It originated in the south-east of Asia. Tea cultivation has had recent success in the Hengduan Mountains and the Himalayas of southern Tibet, originally regarded as an unfavourable area for growing tea. (Zheng et al. 1993). In Pakistan, tea has been suc-

cessfully cultivated on an experimental basis in Mansehra.

Components

The green tea cultivar is Sci No. 21 and for black tea, the cultivars are Shu- Yong No. 3, No. 307, and No. 808. These are cold resistant cultivars. In the Himalayas, tea species were mainly introduced from the Sichuan and Yunnan Provinces, China. Two large-leaf and small-leaf species are now cultivated.

The most suitable temperature for tea plant growth ranges between 20 and 25°C. A temperature above 35°C may cause damage. Similarly, a temperature lower than -15°C will cause most above ground plants to die. The water requirement is at least 888mm annual precipitation. Tea plants grow successfully on well-drained, acidic soils with a pH of from 4.5 to 5.6 (Zheng et al. 1993).

Soil factors in the Himalayan soils are favourable to tea cultivation because the whole soil profile presents an acidic reaction. The plantation may be distributed at elevations between 1,000 and 2,500m on the southern flanks (Zheng et al. 1993).

Floriculture

Significance

Hilly areas are important sources of cut flowers, bulbs, and plants for the lowlands. Cut flowers are marketed in the off-season for income generation. Floriculture is an attractive proposition for HKH farmers and enables them to increase their farm incomes. There is great potential for developing floriculture at the farm level by supplying cut flowers, cut foliage, bulbs,

Plate 41: ***Commercial Tulip Production in Arid Mountains***

tubers, corms, seeds, live flowers, dry flowers, foliage, and perfumes. These are high in value compared to any other horticultural crop (Swarup 1993).

Components

There is great demand from the florists of metropolitan cities for cut flowers. Among the flowers, the orchid is one of the most fascinating, long lasting, and expensive. Important wild orchids of the northeastern Himalayas are *Cymbidium*, *Paphiopedilum*, *Dendrobium*, *Vanda*, *Pleione*, and *Phaleonopsis*. It is not difficult to produce plants and cut flowers of these species. *Gladioli* flowers from Shimla, Nainital, and Srinagar are supplied to florists in the major cities of the plains during the off season (i.e., June to September) at a considerable price. The domestic rose can be grown profitably for essential oil in the

Kashmir Valley and other similar areas of the Himalayas. A private firm in Kochi, near Shamble (H.P.) is producing pot chrysanthemums in polythene houses for marketing during the summer months in major cities. The HKH mountainous region is ideally suited for growing temperate flowers such as the daffodil, narcissus, lily (Easter and Tiger), iris, peony, hyacinth, and tulip. Lavender can grow well on the slopes of Jammu and Kashmir and the highly valuable lavender oil is used in cosmetics (Swarup 1993).