OBSERVATIONS AND DISCUSSION

SOIL AND WATER MANAGEMENT TECHNIQUES

In mountains irrigation has been practiced as an art for about 3000 years now. Historical records bear testimony to the existence of a number of irrigation works in different parts of the country. In the Himalayas, the perennial river Ganges made it relatively easy to divert its flow through inundation channels. In the south, where rainfall is scanty, the practice of trapping rain water in large tanks and ponds for agricultural purpose is widely adopted.

From time immemorial, surface irrigation methods have been followed. The most effective irrigation method for a particular area depends on the slope of the land, the nature of the soil, the type of the crop and availability of funds.

In Kinnaur water continues to be the scarce commodity not only for irrigation but even for drinking and other domestic uses. This difficulty has been experienced very frequently, inspite of the fact that important river namely Sutlej and its tributaries originate from these hills. The existing resources are further declining due to heavy biotic pressure and lack of management of existing resources. Most of our Agricultural/ Horticultural activities are carried on under rainfed conditions and this requires proper management of available water to be conserved for dry periods.

Sources of Irrigation Water

In the hill region, the scope of boring tubewells, canals and even lift irrigation is limited, such facilities are confined to the low lying areas. Therefore, the most common source of irrigation remains the small water channels locally called Kuhls which in fact accounts for 85.83 per cent of the total area under irrigation in hills (Fig 1).

Some villages get water for irrigating their lands from some perennial torrents. The source of irrigation water is generally local nullahs. Glacial water which forms the prime source of sustaining life in the region is brought to the field by making Kuhls (Water Channels).

In Kinnaur and other regions, the source of irrigation as well as drinking water is melting snow on the high peaks which runs downward in the shape of small and big nullahs (streams) and also spring out at certain points.
Fig 1. Well planned Kuhl irrigation water distribution system

Fig 2. 'Kuhl' - open channel irrigation system
Construction of kuhls (water channels)

Kuhls (water channels) are built along the hill gradient for maintaining proper gravity for irrigation (Fig 2). The technique for the preparation of kuhls for irrigation purposes seems to have originated since Babylonian times. It is still one of the commonest ways of bringing water to the crops. If the river has a steep gradient, water is diverted into a canal some distance upstream and led along a contour so that it can flow to fields by gravity.

Kuhls (wooden water channels) are generally made by making notches at the natural water sources and the water is diverted to the fields for irrigation to different terraces, using the natural gravitational flow of water (Fig 3). Since the topography of the area consists of very high slopes and rocky terrains, wooden water channels are used at many places as water passes from one place to another. The water channels are built and managed by the villagers with no government assistance.

In west Himalayan cold deserts for the optimum harnessing of water for irrigation, water channels are constructed along the natural gradients. The irrigation channels (kuhls) are diverted from river tributaries by making use of the natural gradients thus the level of water is higher than that of the cultivated fields.

In upper Kinnaur, the channels (kuhls) are simply dug in the ground to regulate the flow of water. However, where the digging of channels is difficult or the channel has to pass through a village path, underground channels covered with slates are constructed. However, in some parts the wooden channels are also used which are put like a bridge over the path. These channels are made by making a deep groove in the tree trunk or a rocky branch.

Distribution of kuhl water in fields

Participatory management is employed for distribution of water. All disputes regarding the distribution of water through kuhls (water channels) are amicably settled without hampering the water requirement of any period.

All the irrigation channels (kuhls) cannot be run satisfactorily due to non-availability of sufficient water from Nallahs/Khads. This is because of scanty snowfall during the winter months. The majority of hamlets, which lie on the plateaus on the sides of main river get water from the streams which trickle down from the cliffs overhanging the plateaus. These hamlets are the worst off for water, for in the year of scanty snowfall, the streams dwindle quickly and dry up in the beginning of August. Additional snowfall in winter results in less water in natural springs during the season,
Fig 3. Wooden water channel

Fig 4. Irrigation water application

Fig 5. Irrigation water distribution with provision of indigenous control system
whereas less snowfall in winter results in the reduction of level in natural springs during summer and consequently crops suffer.

The farmers have developed the irrigation water distribution system on the basis of their land holdings, in which every field is irrigated timely. So there is no dispute regarding the maintenance of kunds and irrigation water distribution.

Nallahs passing through a village are harvested on turn basis called pala. Temporary channels are dug by the farmers towards their fields. The whole community is divided on the basis of number of farm families and one family gets one full water day to irrigate its fields turn wise. For example, if there are 20 farm families in a village, the turn falls after every 20 days. But two adjoining families may share the water for half day each when there is turn of either of the two families. This way these two families get a chance to irrigate their fields after a gap of 10 days rather than 20 days. This way the distribution of water is so well managed that maximum use of water takes place in a particular village. The turn of a family comes/starts around 2000 to 2200 hrs on a particular day and all the members of the family are engaged in the job on its turn.

In upper Kinnaur, the irrigation technique is much more pronounced. The fields are generally divided into small compartments by making earth bunds to allow water to stand in the field for a longer duration for saturating the soil (Fig 4). Hence need for second irrigation arises only after 20 to 25 days even in those agricultural crops which otherwise require irrigation after a gap of 10-15 days. At the first turn of irrigation, first compartment is irrigated; followed by second and so on. On the second turn of irrigation, however these compartments are irrigated in reverse order, i.e. sixth compartment is irrigated first followed by fifth and so on.

In temperate areas of cold deserts crop cultivation without irrigation is not possible because precipitation takes place in the form of snowfall. People take advantage of glacial water and perform collective operations for effective distribution and ensured supply of this scarce source. The management of water in a particular field is regulated by apportioning into different compartments because of the season. The month of first compartment is closed to regulate the flow of water towards the second compartment (Fig 5). The same method is adopted to irrigate the following compartment. This results in raising the height of channel in front of the first compartment than the channel in front of the second compartment and so on. Now when this field is irrigated during its second turn, the water flows straight towards the fourth compartment. This practice prevents the washing off the upper fertile layers during irrigation.
Fig 6. Water mill (outside)

Fig 7. Water mill (inside)
In the upper Kinnaur, the first irrigation done 40 days after sowing of crop takes place during April. In the initial stage of watering from the Kuhl to field, the ladies bring water to the field by the use of Urna which is made from animals horn. As per the turn pertaining the Baraghant watering/irrigation is done by constructing small beds in the fields. This method is time consuming and laborious. But on the other hand this method checks the loss of nutrients by leaching. Uniform watering of the plants with equal flow, checks the nutrient loss from field to field and from one bed to another.

Use of kuhl water for running water mills

Kuhls are built along the hill gradient for maintaining proper gravity for irrigation and running water mills (Fig 6 & 7). Wooden water channels are also used for running water-flour mills. These wooden channels are generally made by making matches at the natural water sources and the water is diverted to the water mill, using the natural gravitational flow of water. Since the topography of the area consists of very high slopes and rocky terrains, wooden water channels are used at many places as water passes from one place to another.

Granite stones are used for grinding food grains. Long wooden channel placed at steep gradient is used for maintaining the high speed of the water flow. This is necessary for maintaining the high speed of the water mills wheel (Fig 6 & 7).

Now a days water mills are very rare. Water mill technology is in an extinct stage, because of power supply availability and less grain production. Food is purchased from cooperative societies or private shops now a days.

Method of Irrigation

Flooding of glacial water for higher crop productivity

In most Himalayan cold deserts water is brought in channels from glacial melts for irrigating the fields. Flooding the fields with the glacial water for improving crop productivity is also common.

The deposition of fresh silt with unweathered minerals (especially lime) forms glacier source of fresh salts. The glacier melted water is often below 2°C which protects the crop from different kinds of diseases.

Indigenous drip irrigation

The practice of using pitcher water as a source of irrigation on new fruit plantation in sandy loam/loamy sand soils, in areas of scanty rainfall is prevalent in temperate
districts of Himachal Pradesh. The pitcher is placed in soil and the new plant is planted close to it. The pitcher is filled with water during summer months (April-June) and stone/slate lid is placed on the top. The roots draw moisture/water from pitcher which in turn reduces the mortality. The pitcher once filled, supply sufficient moisture for at least two weeks and then again it is filled with water.

Manual irrigation in vegetable

In the initial stage of watering vegetables, people bring water to their fields with the help of buckets (Fig 8) and in Spiti valley ladies bring water to their fields using Urma which is made from animals horn. In this method after bringing water in buckets, water is supplied to the vegetables with the help of iota (mug), whereas in case of Urma, irrigation is done by constructing small beds in the fields. But this method is too laborious and time consuming.

WATER HARVESTING METHODS

Small ponds for spring water collection

Another method is the collection of spring water in small reservoirs scattered at intervals on the high uplands and then drawing water from these ponds when required (Fig 9 a,b & c). Water from these ponds is used for irrigating crops and also for drinking purpose.

Harvesting of dew and fog water

In plains and in valleys occurrence of dew and "Pala" is very common after the receding of monsoon. After monsoon the humidity remains quite high (85%) in the atmosphere. During night time, temperature falls down sharply resulting in the formation of more water molecules from vapours. As they are heavier, they fall on soil surface and make the layer moist and wet.

In the hills, there is traditional practice to plough the field early in the morning before dew or fog water is evaporated. By ploughing, moisture is mixed with soil particles in the plough layer i.e. 9" - 12". This moisture is well retained by soil. If soil is clayey in nature, retention of water remains for a longer time and becomes a source of soil moisture. It is quite useful for land preparation in October-November and for the sowing of rabi crops like wheat, barley and pulses.

Harvesting of water from snow melting

Harvesting of water is also done by constructing water ponds and water is collected in these from melting snow (Fig10).
Fig 8. Hand watering in vegetables

Fig 9a. Well planned spring irrigation water distribution in field

Fig 9b. Village spring water pond for drinking water

Fig 9c. A tank of spring water ‘Bawrt’
Moisture conservation Through Mulching

In Kinnaur, covering the surface of soil with chilgoza tree needles and grass from the Kandas (hill tops) is a common mulching practice (Fig 11). Mulching conserves soil moisture in the fields. It also helps in the moderation of soil temperature. In this way hydro-thermal regime of soil is improved. However, the continuous use of chilgoza tree needles increases the acidity of the soil.

In the hilly areas, ploughing is done, which aids in moisture conservation, as the soil acts as mulch.

Farmers regulate optimum irrigation by inserting a beleha (spade) in the soil. If it is completely inserted (front portion), the land is considered to be properly irrigated. Similarly, in a few other cases, mud is thrown in the air. Its splitting into pieces shows proper irrigation. Complete insertion of the front portion of beleha (spade) or throwing of mud in the air and its consequent splitting into pieces indicate the soil moisture level at field capacity, where 100 per cent moisture is available to the crops.

Drainage

During rainy season the rains are torrential, which causes splash erosion resulting in the sorting of particles and the formation of false compact layer on the surface. It yields water ponding and subsequently water logging. Crops such as maize, capsicum, tomato which are grown during this season are very sensitive to water logging. In our traditional agriculture there is a common practice that during the preparation of a field the slope of a field, is kept inside which is provided with a channel to take excess water from that field to a safer place, from where it is disposed to stream or nullah through grassed water ways. The grassed water ways are kept permanently and help in the drainage. These channels and grassed water ways are positioned in such a way that they do not hinder any agricultural activity such as ploughing, hoeing and harvesting.

SOIL MANAGEMENT

Cultural practices

In the month of March/April, when snow melts and weather condition improves, the bunds and corners of the fields are dug-out and weeds and grasses are removed with the help of spade and clods. The grasses or weeds are beaten up and then soil is separated from these clods and collected in lower fields.

This practice of removing weeds and grasses from bunds and corners by digging helps in weed control in the cultivated fields. Secondly area under remains the same as
Fig 10. Village water pond where water is collected from snow melting.

Fig 11. In situ moisture conservation with locally available tree leaves and grasses.

Fig 12a. Stone terrace making.

Fig 12b. Stone terrace wall.
that previous crop i.e. area is not wasted from weeds and grasses. Thirdly the soil added in lower fields from the bunds of upper field is rich in nutrients and it improves the soil fertility.

In central west of the capital of Medagaskar bury pieces of banana stem and leaves around the stringa weed growing in maize and paddy crops. Stringa inhibits the growth of maize and paddy there due to which the plants become yellow. This practice the growth of stringa is stopped. The farmers of Nigeria are fed up with stringa weed which harms their sorghum crop. Farmers grow sesame with sorghum. Stringa makes potato like tubers on the sesame roots which the farmers remove and save their sorghum crop (Oliver, 1997).

In Shimoga (Karnataka) farmers grow coriander in the Jowar crop. Stringa weed which grows in Jowar is surrounded by coriander plant which stops the growth of weed (Rao, 1998).

Use of broader plough in upper valleys

Ploughs are broadened in upper Kinnaur by attaching flat wooden pieces to both sides of the iron blade. This indigenous plough is preferred over the one available in the market.

This technology seems to have two fold functions of saving labour and that of stabilizing the loose sandy strata in one ploughing action, which suits the small terraces.

Sheet erosion control

It is not a damaging form of erosion, mainly because it is often not recognised and seldom treated. It accounts for the loss of billions of tonnes of soil every year. Due to splash of rain drops particles are knocked loose and then carried away by the runoff. The sheet erosion results into rill and gullies which are controlled by very cheap treatments. Sheet erosion is more apparent in forest areas that are devoid of ground cover or wastelands with very few standing trees.

There is traditional practice to keep surface maximum covered with grasses, shrubs etc. Grazing is done in rotation and is allowed only during certain times. It is avoided during the flowering and seed setting stages of grasses. Fibrous rooted shrubs and grasses planted as hedges along the contour of the land slow the runoff, weaken the erosive power of water and cause it to deposit its load of valuable soil behind the hedge rows. As a result the runoff proceeds gently down the slope where hedges have been planted at the correct vertical interval without erosive effect. In the foot hills, erosive capacity of stream flow is also reduced by spurs of loose boulders.
Traditional rainfed farming
Most of the area is rainfed or dependent on snowmelt except for a few pockets in valleys where irrigation facilities are existing. The choice of crop and rotation, completely depends on crops which require less volume of water. For rotation, legumes are important as mixed crop. During rotation, when rainy season erosion permitting crops are grown, such as cowpea, 'ktut', these form integral part of the mixed cropping system. The crops are chosen as per their nutrition e.g. from old ages protein rich pulses are part of cropping pattern, the coarse grains like 'phaphra', 'chulai' are also grown very commonly which are very rich in nutrition.

The fields are well protected with biofence of thorny shrubs or their cut pieces. The traditional rainfed farming in done irrespective of land with respect to slope and other characteristics. There are chances of sheet erosion but with traditional knowledge, crop rotation is adopted in such a way that during peak runoff periods sowing of close growing crops provide protection to the soil.

Terracing
From old times, land in the hills has been put under cultivation on scientific lines as cultivation is done up to 25-100 degree slope, where there are many chances of landslips, sheet and gully erosion. But with bench terracing practices the menace of soil erosion is controlled and is very common in hill farming.

The terraces are constructed across the slope i.e. along the contour (Fig 12 a, b, c, d, e, f, g & h). The size of the terrace is decided by the prevailing degree of slope. The terraces are supported by risers of suitable heights and width. The height of riser is again decided by the degree of slope. The risers are sometime made of loose boulders supported by grasses. The roots of grasses help in binding and keeping the boulders intact at a pace. The roots of grasses help in drainage of excess water. With the traditional knowledge, farmers are keeping the risers toward inner slopes. In paddy growing areas the risers are erected to facilitate the ponding of water in the field. This type of bunding and terracing is continuing from centuries and terraces are still intact. In the lower Kinnar bunds are again used for growing palatable grasses which is used as fodder for livestock and trees are meant for fuel, fodder and fibre. In lower areas the bench terraces are known as "khet". Sometime on the risers contour hedge of grass like khus, local grasses are also established.

Use of maddim (a plain wooden structure) for field levelling
Maddim is used for levelling ploughed lands. A heavy stone is put on the maddim for increasing the pressure required for levelling. Sometimes, a man may also sit instead of a heavy stone.
Fig 12c. Traditional symmetrical terraces

Fig 12d. Terrace slicing in crop field

Fig 12e. Earthen terraces

Fig 12f. Crop field terraces and community forestry

Fig 12g. Stone terraces along the slope
Such an indigenous technology for field levelling is called planking. With this practice, there is very good seed soil contact and very good germination of the crops. Secondly, there moisture conservation in the fields. Thirdly small soil clods are pressed and broken into finer particles and this way soil structure is improved.

Curved land ploughing for intensive land preparation, soil conservation and water retention

Ploughing is done in a curved (sword like) manner from the bottom to the top of the slopy land holdings.

Ploughing land holdings in a sword like pattern ensures proper land preparation which includes proper ploughing of the corners which otherwise would have remained unploughed. The ploughing of slopy lands from bottom to top also helps in soil conservation as it checks the loosened soil strata falling from the upper side to the lower. The curved pattern is useful in maintaining infiltration rate of water which otherwise gets wasted with sudden runoff.

Conserving productive soil layer against wind erosion

In cold deserts, fields are irrigated in autumn so that the top layer is prevented from being blown away. In spring the moistened soil eases ploughing.

The productive soil layer, which is very thin, needs conservation against heavy wind erosion, a common feature of the cold deserts. This appropriate soil conservation technique also helps in easy and timely ploughing for meeting the requirement of short growing season. The moist upper layer of soil which gets frozen in winter also serves as a protection against wind erosion.

Cultivation of levelled/flat lands for preventing soil erosion

In cold deserts, cultivation practices are confined to the levelled/flat lands only.

This practice helps not only in the rational land use but also checks soil erosion in otherwise sandy and loose strata.

Contouring of slopy lands: Ethno-engineering for soil conservation

In cold deserts farmers have developed this technology for cultivation of slopy lands by constructing terraces comprising of plots and sub-plots by using small stones. Stone wall fencing is also constructed for individual land holdings. Terracing of slopy lands helps in conserving soil and moisture and prevents soil erosion. This also helps to carry out other field operations including proper use of irrigation water for checking the surface runoff.
Fig 12h. Bench terrace fortified with vegetative measures

Fig 13. Loose boulders spurs - reduce cutting effect of stream flow in 'choes'

Fig 14. Green pine needles cut into pieces before spreading for bedding in cattle yard
Use of loose boulders spurs for reducing soil erosion

In some areas, people use loose boulders spurs for reducing the cutting effect of stream flow in a small nullah (Chawn) (Fig 13).

Soil Fertility Management

Proper soil management, ensuring continued maintenance and building up of fertility at a high level is indispensable for the profitable use of agricultural lands. While chemical fertilizers introduce extra concentrated supplies of readily available plant nutrients to the soil, the beneficial effect of organic manures predominantly lies in furnishing humus forming material to bring about improvement in the soil structure, water holding capacity, microbial population and its activity, base exchange capacity and resistance to soil erosion. Much of the plant food removed by the crops is restored to the soil through the application of organic manures.

Soil management by crop residue harvesting

This practice is prevalent in cold deserts. Barley and wheat stumps are pulled out by hand along with the complete root system. Soil is softened by a light irrigation a day before. Wheat is often pulled out while standing, but kneeling or squatting is practised for barley. Handful of these plants are beaten up against the legs (occasionally a small apron is worn) to shake off most of the earth. These bundles are then piled up like the tiles of a roof. The ears of the lower row are covered and protected from birds by the roots of the upper stacks. Barley and buckwheat (in double cropping farming system) are also pulled out by roots. This helps in uprooting weeds, soil loosening and porosity maintenance for the coming crop.

Other practice is to harvest crops as close to the grounds as possible. The roots are made to stay in soil for humus production. Very little plant material (stem and roots) is allowed to be left in the soil as a protective measure against the soil borne diseases. This practice also increases the fodder resource in winters. Retention of roots in soil (in single cropping) contributes towards humus availability which improves the soil structure, porosity and water holding capacity of the soil.

Soil mixing with night soils

Soil with human excreta is mixed and broadcasted over the fields during winter months. Soil is collected from cultivated land holdings and particularly from field bunds of sub-plots for mixing.

The night soil/human excreta possess immense manorial potentiality as it contains the major plant nutrients like nitrogen, phosphorus and potassium. So the addition of
night soil/human excreta along with soil from cultivated field improves the soil fertility. The practice of collecting soil from cultivated land and fields helps in easy ploughing during summer cropping.

**Organic manuring, collection and management**

Organic manures derived from plant and animal resource, are valuable byproducts of farming and allied industries. Organic manures which are bulky in nature but supply the plant nutrients in small quantities are termed as bulky organic manures e.g. farm yard manure, rural and town compost, night soil, green manure etc., whereas those containing higher percentage of major plant nutrients like nitrogen, phosphorus and potash are known as concentrated organic manures e.g. oil cakes, goat manure, sheep and poultry manure, blood and meat-meals, etc.

Flocks of sheep and goats, contribute towards tribal economy by way of milk, meat, wool and manure. These flocks when taken for grazing are tied with small bags which cover their anal parts so that the excreta falls right into the bag.

This region is highly sandy with low soil fertility status. The collection of dropping of sheep and goats by tying bags is indicative of indigenous wisdom to meet out the shortage of manure. This manure of the dropping of sheep and goats contains 3% nitrogen, 1% phosphorus and 2% potassium.

In upper Kinnaur, organic manuring is done once a year because of mono-cropping pattern in the months of September-October after the crop. The manure is broadcasted in the entire field, which is followed by ploughing for thorough mixing. The richest manure is called Chakka which comprises of human excreta and is collected in separate dry latrine pit. The man reason for its nutritional value is that even the bones of animals are thrown in the excreta which add phosphorus and calcium to the manure.

The daily per capita availability of night soil, human urine and nutrients contained in it is as under:

<table>
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<tr>
<th>Particulars</th>
<th>Faeces (g)</th>
<th>Urine (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity (natural condition)</td>
<td>133.00</td>
<td>1200.00</td>
</tr>
<tr>
<td>Quantity (dry)</td>
<td>30.30</td>
<td>64.00</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>2.10</td>
<td>12.10</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>1.64</td>
<td>1.80</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.73</td>
<td>2.22</td>
</tr>
</tbody>
</table>

113
This data shows that night soil and human urine have a great manural potential with regard to nitrogen, phosphorus and potassium. Due to this potential, it is considered good manure by the farmers.

Secondly cattle dung is collected in heaps within cattle sheds during winter months, so that it decomposes under relatively high temperature conditions. Then it is placed out in the open during summer in the form of heaps for further decomposition. Actually the cattle dung contains 0.2% nitrogen, 0.1% phosphorus and 0.15% potassium and cattle urine contains 0.6% nitrogen, 0.1% phosphorus and 0.5% potassium. Due to these immense manural potentialities of cattle dung and urine, the use of this manure is very much popular among farmers. The traditional means of manure are as follows:

i) Dung of livestock, mostly cattle, collected from the sheds, pens and camps of livestock.

ii) The leaves and grasses which were used as bedding for the animals, got soaked with the excreta/urine of livestock and were then collected periodically.

iii) Feeding of sheep and goats in the fields:
The method of manuring is very much in vogue in those places which are visited by the Gaddi graziers, whether enroute to their camps or on move with their herds. The Gaddis are paid for this benefit. These traditional practices continue unchanged. The only improvement that has been made is that the heaps of cow dung are well covered with something or the other in order to protect them from rains and snow.

iv) In the wet temperate areas, green and dried pine needles are collected in heaps and used as bedding material (Fig 14 & 15) Before using as bedding material these pine needles are cut into small pieces.

In the absence of chemical fertilizers, organic manuring is the chief mode of soil fertilization. All efforts are made to collect and use animal droppings and for their subsequent decomposition along with the leaves and grasses which are used in manuring the crops. This is the traditional organic manure and is most readily available to the farmers. It is the product of decomposition of the liquid and solid excreta of livestock, stored in the sheds, pens and camps of livestock along with varying amounts of straw or other litter used as bedding. This farmyard manure/compost prepared from farm litter, liquid and solid excreta of livestock contains 0.5% nitrogen, 0.2% phosphorus and 0.5% potassium.

To enhance the productivity, people in Kinnaur still use the farmyard manure. It is worth mentioning that here animals are kept primarily to meet the need of manure.
Fig 15. Green pine needles spread for bedding in cattle yard

Fig 16. FYM heaps

Fig 17. FYM heaps in the field

Fig 18a. Transport of FYM in 'Kolta'
Donkeys, cows, goats and sheep are the main source of manure. The manure is collected either from the cowsheds inside the house or the cowsheds outside the house. Generally, the ground floor in each house is used as a cowshed so that animals can be looked after in a better way during winter months. The dung is put outside the house in a heap form in lower areas, whereas, in upper areas, it is directly put in small heaps in the fields (Fig 16 & 17). These small heaps of dung are covered with a thin layer of soil to avoid the dispersion of manure by wind. The manure is directly mixed with the soil while ploughing. Farm yard manure is transported to the fields in Kulta (bamboo container) by people's participation (Fig 18 a,b & c) and also by horses (Fig 19).

Amongst the manures, the cow dung is preferred the most. According to most farmers the sheep and goat dung may lead to burning of crops if applied in excess. Ass dung though used is not preferred much. On an average 125 to 250 qtls of manure is used per acre by the farmers throughout the Kinnaur region.

The practice of keeping small heaps of manure in open field with soil coverage in high altitude zones helps in better decomposition due to the maintenance of better temperature conditions. Use of sheep and goat manure in large quantities leads to burning of crops. The burning of crops is due to the toxic effects of high levels of nitrogen, phosphorus and potassium in goat and sheep manures. The goat and sheep manure contains 3% nitrogen, 1% phosphorus and 2% potassium.

USE OF ASH

i) Nutrient recycling

The inhabitants of this entire region use cattle dung, shrubs and bushes as the main source of fuel. Ashes available, there upon, are mixed either with household waste or human excreta. Sometimes ashes are also broadcasted in the fields.

Mixing of ash with household waste and human excreta aids in nutrient availability and recycling. Ash primarily meets the deficiency of potash. Availability of phosphorus is also ensured. In addition to this, human excreta and household waste also contains good amounts of nitrogen, phosphorus and potassium.

The cow dung and urine have been used for manure making in other parts also.

The farmers of Haryana, to make special manure, take 4 kg cow dung, 8 L urine and 250 g molasses in a earthen pitcher which is kept for seven days. One litre of it is mixed in 4 litre water to drench the vegetables (100 ml per plant in case of cucurbits,
Fig 18b. Transporting FYM to field

Fig 18c. Peoples' participation in FYM transport

Fig 19. Transport of FYM on horses

Fig 20. Biofence - common in hills
brinjal etc.) and fruits (250 ml per tree in case of mango, guava, pomegranate, banana, jamun etc.) (Anon, 1999b).

The 50 kg ash is put in a pit and mixed with 10 L cow urine. This is used 60 kg per acre after dew. It is believed that it has the quality of urea (Anon, 1999 b).

In Panchmahal (Gujrat) put 6 cm layer of kitchen waste, vegetable pecl, grasses and leaves in a pit of 10x10 ft. followed by 50-100 kg Thor (Euphorbia nerifolia) chopped plants to a height of 1 foot. The top is covered with cowdung and then dry grass. The compost is ready after one year which is very useful in wheat crop (Anon, 1999 b).

ii) Softening of hard soils
Soils are softened by putting ash obtained from cowdung, sheep/ goat manure, fuelwood etc.

Through this practice upper layers of soils are not only softened but their fertility status is also improved, as ash contains phosphorus.

iii) Increased size of potatoes through the use of ash and goat manure
A mixture of kitchen ash and goat manure is used in kitchen gardens for growing potatoes.

The spreading of this mixture as an organic manure, increases the size of potatoes on account of optimum supply of nutrients in otherwise nutrient deficient soils. Secondly organic manure improves the soil structure, porosity and water holding capacity of the soils. In this way there is an overall improvement in physical, chemical and biological properties like microbial population etc., which has increased the size of potatoes.

Stage of farm yard manure in cultivated fields
In deserts, FYM with a thin coverage of soil is kept in small heaps in the fields from October to March. With the onset of summer months it is spread in the open field.

Coverage of organic manure (FYM) with soil in open fields throughout winter helps in regulating (heap) temperature necessary for proper decomposition of FYM.

Use of goat manure
Goat manure is considered to be more nutritious. Goat manure when added to millet fields improves production. Goats are specially penned in these plots/ fields.
SEASONAL SHEEP AND GOAT MIGRATION

A GADDI AT HIS DOGRI (SECOND HOUSE)

WOODEN GRAIN STORAGE HOUSE

TERRACING AND SUB-PLOTTING OF FIELDS
Goat manure improves not only the millet production but also its taste. According to farmers, vegetables grown in goat manure have longer keeping quality. It is easy to plough fields manured with goat excreta. Actually with the addition of goat excreta, there is improvement in the physical properties like soil structure, water holding capacity and porosity. There is also an improvement in soil fertility as it contains 3% nitrogen, 1% phosphorus and 2% potassium.

**Biofencing with seabuckthorn (Hippophae rhamnoides)**

This practice is prevalent in upper Kinnaur and other regions. There is a common practice to provide biofencing with seabuckthorn in cold deserts in general and Spiti in particular (Fig 20).

The biofence of seabuckthorn being thorny in nature protects crop from stray animal. Its multipurpose utility as a nitrogen fixer, checks against soil erosion, conservation of soil and moisture, source of fuelwood and indigenous drug (rich source of vitamin C) makes it a promising plant for eco-economic rehabilitation of the region.

**Sprawling of ash dust in cucurbits and other vegetable crops**

In the cold deserts, ash dust is a product obtained after the combustion of fuelwood. It has been observed that dusting of material in the fields enhances early maturity and high yield of vegetable crops.

The reason for the early maturity of cucurbits and vegetable crops is due to the fact that ash dust contains sufficient quantity of phosphorus in available form to the plants. Secondly, in cucurbits the ash dust has been used to repel the insect pests of the crops. Thirdly, amendments of ash dust in the soil, improves soil structure and fertility. Ash dust is also useful in enhancing the maturity of bulb crops which normally takes 6-7 months for obtaining economic yield.

**Drought power according to soil texture**

In cold deserts, ploughing is generally carried out by dzos, however in sandy situations horses are employed for its speedy completion. Sandy soil have less soil strength than clayey soil. Due to this reason, the drought power requirement for ploughing varies according to soil texture.
FORESTRY AND AGROFORESTRY MANAGEMENT PRACTICES

SILVICULTURE

Wood lots

i) Sacred wood lots: It is an old traditional practice to conserve and protect an entire forest or a small wood lot in the name of the village deity (Kal Dawa). This is prevalent in every village of the mountainous region of India, particularly so in Himachal Pradesh, Garhwal and Kumaon hills and also Kashmir hills. A temple along with a hut or shelter is constructed to keep the items/untensils of the village deity. All religious rites are performed in its complex and no body is allowed to fell the trees. It is also seen that a perennial water source is managed either in the forest or near it, for common use by the village for drinking purpose.

ii) Private and community wood lots: Community and private forests (wood lots) are protected at the community level. In community forests, the whole area is divided into small block or compartments and each compartment is allotted to the inhabitants for rotational lopping of fodder particularly oaks woodlots during lean (winter) season. Frequent fuel wood collection is permitted only in case of twigs and/or branches which are carried and stocked in a traditional manner (Fig 21 a, b & c).

Villagers employ or engage a caretaker for the protection of private or community forests. No one is allowed to lop and cut trees for fuel wood. If someone is found doing so, the caretaker confiscates his/her sickle/axe and ask him/her to appear before the village panchayat, which imposes a penalty on him/her in the form of monetary fine or otherwise. Every household in the village contributes some grain or cash in each crop season for the caretaker’s maintenance. In water logged areas along with Kuhl or nullahs people raise plantations of salix (Bhains), Almus (Kunish) or other moisture loving trees. Farmers make extensive use of the wood from both private and community forests for building all kinds of houses, shelters etc. (Fig 22 a, b & c) and have devised their own technologies for postharvest processing of the wood (Fig 22 d & e).

Traditional minor forest resource management

In the lower hills of Himachal Pradesh, Uttarakhand and of Jammu & Kashmir, Acacia catechu (Khair) for katha, Pinus roxburghii (chirpine) for resin, Acacia nilotica (Kikar) for tannin and gums and Grewia optiva (Beul) for fodder and fibre are well
Fig 21a. Firewood collection

Fig 21b. Firewood collection

Fig 21c. Stocking of firewood

Fig 22a. Traditional roofing made of wood and slates
Fig 22b. Mountain wooden house  Fig 22c. Traditional mountain woodhouse

Fig 22d. Timber sawing  Fig 22e. Timber saw
known. The villagers manage and protect these trees/wood lots and obtain high economic returns. These wood lots are inaccessible for fuel and timber requirements. The villagers also get seasonal employment in these forests for the collection of value added minor forest products. Similarly in the Kinnaur district of Himachal state, which is known for the production of *Pinus gerardiana* (chilgoza) seeds and *Prunus armeniaca* (chuli) fruits, the local people have right to collect the same from the forest and to sell them in the market for economic remuneration. The government forests of these species are managed by the villagers as common properties. These forests are divided into small blocks and each block is allocated to a family for protection, management and collection of produce.

**Homestead agroforestry system**

A homestead or homegarden is an operational farm unit in which a number of tree species are raised along with livestock poultry and/or fish, mainly for the purpose of satisfying the farmers basic needs. This farming is traditional in the Himalayan region. In a homegarden multiple crops are present in a multi-tier canopy configuration. The leaf canopies of the components are arranged in such a way that they occupy different vertical layers with the tallest components having foliage tolerant to strong light and high evaporation demand and the shorter components having foliage requiring or tolerating shade and high humidity.

Similarly in the Agri-horticultural system which is predominantly followed in the mid-hill-sub humid and high hill-temperate wet zones fruit trees are grown on terrace bunds along with agriculture crops since fuel and fodder are readily available from other sources. Agricultural crops like peas, cabbage, pulses are generally grown in the inter-spaces of horticultural trees such as *Malus domestica* (apple) *Prunus domestica* (plum), *P. armeniaca* (apricot) *P. persica* (peach), *P. denuda* (almond) and *Pirus communis* (pear) fig. 23. Trees are uniformly spaced in the field and average density of trees is generally 5 per 100 m². In some cases fuel or fodder/timber trees are also retained on the field bunds and managed under agri-horti-silvicultural system. Besides providing fruits/fuelwood/fodder trees grown along bunds also restrict/check erosion.

**Private and community fodder wood blocks**

Fodder tree forests in the vicinity of villages, be they on forest land, community land or private land are jointly managed by the managers to meet their fodder need for cattle during lean period i.e. winter season. *Quercus* spp. (oaks) forests are jointly managed and protected for the same and are managed so as to meet fodder and fuel requirements (Fig 24).

Seabuckthorn (*Hippophae l.* ) an ecological viable and ethnobotanically
Fig 23. Relay farming in which multi-purpose trees are grown with food crops

Fig 24. Lopped and unlopped tree for ladder and fuel

Fig 25a. Seabuckthorn forest

Fig 25b. Seabuckthorn fruits

Fig 25c. Nitrogen fixing nodules of seabuckthorn
sustainable food crop, belonging to family Elaeagnaceae, is one of the few potential resources of high mountain areas which has been reported to offer hope to give multiple benefits to poor mountain man (Fig. 3.5a, b & c).

Seabuckthorn, an indigenous plant which has survived under harsh climate conditions such as average rainfall 350-1200 mm, average temperature in the range of 10-15 °C and sometimes going below -40° to -50° C), is one such species which has immense potential for satisfying all requirements. Seabuckthorn is widely distributed along high hills, river beds, valleys and along dry mountain slopes of this region both as healthy dense stands as well as in scattered gregarious dense patches in an altitudinal range of 700 m to as high as 5500 m and above.

The people in high mountainous areas have been using seabuckthorn fruits for curing several ailments, including skin tumor diseases, digestive disorders and respiratory ailments, foot and mouth disease in cattle, besides using it extensively in agroforestry practices, though the farming community did not know of its exact potential. Seabuckthorn has also been a major source of fuelwood to local inhabitants who face scarcity of other sources of energy. Major traditional uses of seabuckthorn in high mountainous cold and dry zone of Himachal Pradesh are fuelwood, fodder for goats and cattle (nutritious forage), fencing to protect fruit trees/nurseries/orchards, maintenance of traditional irrigation channel besides soil conservation, improving fertility, quality timber, useful for newly opened areas and subsidiary food items, medicinal products and alcoholic preparations.

In Himachal Pradesh major gene pool areas have been identified at Spiti valley, Lahaul and Kinnaur, for 4 species and 9 sub-species of genus Hippophae reported from different parts of the world.

The introduction, promotion and development of seabuckthorn in this area seems meaningful and will not only help vegetation rehabilitation, but also in ecological sustenance and economic gains to local farmers of the cold and dry mountain areas.

**LIVESTOCK AND FODDER MANAGEMENT**

The technologies for increased productivity in respect of animal husbandry include characteristics of migratory grazing by shepherds, health care, veterinary prescriptions and optimisation of animal breeding for milk and draught power. Some of the important ITK systems prevailing in this region are summarised here under:
Migration of Flocks of Sheep and Goats

Migration of sheep/goats from Kinnaur to Dehra Dun commences at the latest by October end with the downward march of goats and sheep from the Paboo (high pastures) where they had been housed in temporary structures during summer. (These temporary structures are often destroyed due to severe climatic conditions such as heavy snow and have to be reconstructed each year). The first halt is in the Rango (also called Kanda, is the highest point where cultivable lands are found above the village), for a few days the flocks are housed in these semi-permanent structures. Subsequently, they travel to the village/ shennang (cultivable lands below the village) again stay there for a few days and then proceed towards the plains. Homeward migration starts around March end/early April, the same route is followed, albeit in the reverse order. The halt at each “station” allows FYM needs to be met and the shortage is made good by Kimze (cattle etc.) which are not allowed migrate but stay in the village/Rango/Shennang. Kimze are retained to meet social, religious, and ritual obligations, besides providing FYM. The people of the area have a well organized system of marking their cattle, generally on the external in the shape of a simple “V” or “U” shaped cut or round or square cut or a combination of two or more of these markings for purpose of easy identification.

The age old practice of manuring fields during October in the lower ranges is still practiced. The landlords not only extend their complete cooperation and hospitality to the shepherds, but even provide them with food and other items in addition to some cash payment for manuring their fields through night droppings.

This grazing practice sustains the grazing pressure. It also enhances the nutrient recycling in these areas to a great extent. Fertilization of fields during the to and fro movement of livestock enhances crop productivity at low economic cost.

For shearing (twice in a year), special scissors are used. Shepherds carry modern drugs with them and are competent enough to administer drugs through injection to diseased animals. A herd of sheep and goats is always accompanied by one or two gaddi dogs. Cereals and pulses which were earlier imported into the district are now being cultivated in the Kandas.

The obvious advantage of this practice is that sheep and goats constitute pastoral wealth and as such yield economic remunerations. Further, pastoral life is an ecological adaptation in an area where land holdings being small, conventional agricultural is not viable.
Traditional Management Practices Adopted by Gaddi Shepherds

The indigenous resource management involving very limited external inputs, developed by gaddi shepherds in difficult and isolated hilly terrain, is an example itself. The resource use is still in vogue, in the areas ranging from alpine pastures down to the foothills and has evolved over generations under to meet the fodder requirements. This agro-pastoral resource use/adaptation is an example of sustenance and sustainability.

Some techniques that have been perfected by the gaddis may be summarised as:

* Crossing high passes without any forecasting device and the timely return for agricultural operations.

* The penning practice for securing grazing facilities and support (food etc.) from other cultivators, involves exchange rate negotiation. Similarly, those villagers who own relatively smaller number of sheep/goats hand over their animals to ‘puhals’ for grazing them nominal charges after due negotiations and duties are shared.

* Their dedication emanates from their religious and cultural orientation centered around Lord Shiva. Their strong engrained attachment to different deities and Lords Shiva helps them face all risks and challenges which are an integral part of the Gaddi lifestyle. Sacrifice of goats is still practised.

* Gaddi rituals and customs to a great extent have also been influenced by sheep/goats. They refer to their flocks as ‘dham’ or ‘mal’ which is a synonym of wealth.

* Isolation for a considerable part of the year, has led them to develop their own system of medicine for curing common ailments.

* Isolation, prevalence of small terrace lands, single growing season, requirement of low technological and other input, high nutritional value and easy storage, dictates that cultivation of coarse cereals-millets (mostly by females) be undertaken. The elderly and a few youngsters occupy themselves with wool weaving especially during winter.

* In west Himalayan cold deserts it is a usual practice to protect small growing trees and tree trunks against foraging by animals, by wrapping gunny bags or small tinsheets around them. This is found useful because such protection prevents tree mortality since goats chew tree bark for tiding over fodder shortages, specially during the winter months.
* **Gaddi** sheep are best suited to the challenges and adventures posed by the system. They can walk continuously for mile together, traverse difficult terrain and can pass snow peaks without any significant damage. They are used as ‘beasts of burden’ in trade and are employed for carrying loads to difficult and inaccessible areas.

* **Gaddi** dogs (sheep dogs), are reputed for their bravery as watchdogs. They continuously move with the flock acting as an effective measure against theft and attack of predators, they also provide companionship.

* The strong bondage between the members of the **Gaddi** tribe is unique, since they have to depend on each other for survival.

Their adaptation to the hardships and diversity of the migratorial grazing system brings into focus the inherent sustainability element. Emerging changes, no doubt, are exerting great pressure, but proper management mechanism will help in the sustainable functioning of the system which enjoys the advantages of inherent soundness and emotional attachments.

**TRADITIONAL METHODS OF ANIMAL TREATMENT**

**Herbal treatment**

Local methods for treating animal diseases have been in use since long. These measures are quite effective and are still in use.

1. Long grasses found in fields are boiled and are fed to animals with stomach ailments.

2. A bottle of **sarson** (mustard) oil is fed to animal for stomach ailments.

3. Bark of **beli** tree is wrapped around the injured portion of animals for speedy recovery.

4. Wool shedding in sheep is overcome by massaging them with a mixture of sulphur and **sarson** (mustard) oil.

5. **Khurda** disease (insect attack on sheep feet) is cured by wrapping crushed leaves of **karnu** tree around the infected feet after washing them with luke warm water.

6. A hot soup of **zira** (cumin) and garlic is fed to animals affected by fever and cold.
7. Garlands of fresh garlic are hung around the neck of cows with stomach problems for effective treatment.

8. Application of human saliva to the suffering eye(s) is a most effective treatment for eyes sores.

9. Burning grass (Jawanlari) along with black cloth and mixing the ash with oil is fed to cows afflicted by dysentery. This grass is dried and stored for winter months.

10. Sanctified soil of terminatorium is sprinkled over a cow afflicted by stomach pain. A cap of any person is then beaten against the body of the cow. A designated person usually sanctifies the soil before sprinkling. If such a person is not available in the village, an expert is invited from another village.

These indigenous methods of treating common ailments are claimed to be highly effective. These methods have the advantage of utilizing locally available materials which have medicinal properties. For example bark of belly tree or crushed leaves of karni tree have a bitter taste, but have antiseptic properties and are fly repellents and thus help in speedy healing of the injured portion.

Sarson (mustard) oil is a source of energy and fat soluble vitamins, it removes constipation and is thus it is recommended in times of stomach ailments. A mixture of sulphur and sarson (mustard) oil helps in the prevention and control of skin diseases and provides nutrition to the wool fiber and thus overcomes problem of wool shedding in sheep. A hot soup made of zira and garlic is analgesic and antipyretic in nature, it improves digestion and thus protects body from common cold. Garlands of fresh garlic, due to their peculiar odour, stimulate the eructation reflex and the treat stomach ailments.

In Kinnaur about 200 ml sarson or wild apricot oil is fed to cattle when they have a swollen abdomen condition. The germicidal properties of the oil help solve the problem.

Locally developed treatments of animals which are claimed to be highly effective, however, lack scientific investigations and thus require further experimentation and critical appraisal/analysis for the broad base application of this indigenous knowledge. This lack of scientific temper is a serious limitation.

**Ethnophamacueutical Care of Cattle**

For the indisposition of cattle, a small cut in outer the portion of ear lobe (of the animal) is made for exudation of blood.
Such treatment is useful/advantageous because in high hills cold and fatigue are the main factors causing minor ailments. The availability of oil from fruits along with boiled water becomes a source of instant energy, minerals, vitamins and antiseptic media for curing the general diseases.

* The exudation of blood is similar to an indigenous medicinal practice for curing certain human diseases more commonly known as the "Humoral Theory of Diseases". The exudation of blood from the infected portion by making an incision helps in the removal of infection, since along with the poison etc. pathogens are also washed away.

To keep yak and dzos healthy, some management practices are followed by the local people viz. these animals are not allowed to drink water after heavy works. This is done by tying their mouths during their return from fields. Similarly, during summer grazing when these animals return to dokras for recouping salt requirement, the animals are tied for 24 hours for checking their water urge. These practices are useful because the farmers claim that the intake of water after heavy exercise in the fields, leads to formation of tumours in the neck region. This may be due to some physiological disturbances and the sudden contraction and expansion of muscular tissue resulting from sudden changes in the body temperature caused by the intake of cold water. Further, the intake of cold water after heavy exercise also results in abdominal colic, which may sometimes be fatal. It may also cause exposure.

* In summer months fodder consumption by yaks and dzos increase their urge for salt which ultimately leads to their desire to consume more water form frequently available glacial streams resulting in inflation of stomach and eventual death in many cases. Heavy water consumption immediately after salt intake leads to the loss of sodium and chloride ions because these two are not stored in the body. Locating salt licks in pastures should be encouraged.

As is evident, the fear of losing the animals has led to the development of these simple practices which require scientific explanation.

* Dysentery is a common ailment of animals. For treating dysentery, a red hot iron is brought near the nose of the animals. It is claimed to be a most effective treatment against dysentery because it probably stimulates the defence mechanism i.e. involuntary contraction of gastrointestinal musculature which in turn may relieve constipation which is the major cause of dysentery. This probable explanation, however, needs to be ratified by veterinary research.
Castration of male sheep may lead to a decrease in testosterone hormone (androgen production) which in turn leads to higher estrogen content which facilitates increased wool production.

Cow urine is also used as medicine. Its antiseptic properties help incuring small cuts and wounds. The exuvae (skin) of snakes is crushed with common salt and fed to the affected animals. While salt has medicinal value no information is available about the curative properties of the exuvae.

Human saliva is antiseptic in nature and has epidermal growth factor which initiates healing process and thus is most effective for eye sores.

With a view to minimize mortality rates offspring birth is managed in such a way so that the birth takes place during April and May to ensure a higher survival rate. This is controlled through isolation of sexes or through the covering of male genitalia during winters.

Severe winters and heavy snowfall cause heavy mortality. The relatively warm climate of April and May and optimum fodder in the pastures and the farms bring about minimum mortality.

'Changspass' use goat and yak hair to weave warm blankets. Goat and yak hair are very warm and the blankets woven from them, help the shepherds in meeting the harsh climatic conditions.

* Dcedar oil mixed with common salt is used to massage the diseased portion of the skin of goats in Kinnaur since both have medicinal value.

* Methi (fenugreek) seeds are mixed with wheat flour and fed to buffaloes in view of the many medicinal uses of fenugreek. Such feeding helps in preventing buffalo from coming to heat.

Against diseases in cattle the farmers use different practices:

- The seeds of toria and mustard boiled in water in equal quantities and feed it to animals after sieving (Una, Himachal Pradesh) (Chand, 1999 b).

- Turmeric powder is mixed with butter and put on Aak stems which is inserted in animals nose (Bidar, Karnataka) (Telanga, 1999).
- Cattle are fed 250 g groundnut oil and onion. Besides Tulsi, Pudina, tea leaves and Ajwain boiled water extract is also given (Rajkot, Gujar) (Kapadia, 1999).

- *Aak* leaves are warmed and put on animal body (Dhangdhara, Gujar) (Malvabhai, 1999).

- *Pipal* and *Zira* fruits are mixed with garlic to form tablets which are given to animals. (Madurai) (Konar, 1999).

- Rub 500-700 g salt on the back of animal for 30 min and also smoke the animal with *Shisham* sawdust (Junagarh, gujar) (Ralu, 1999).

- In case of lashes on tongue and throat people rub their shoes on the tongues of animals (Kargil, J&K) (Sharma, 1999c).

- In case of ache in bull neck, *Kuwar* (*Aloe barbadensis*) leaves are heated in pot, ground and pasted on bull neck (Una, Himachal Pradesh) (Devi, 1998 b).

- *Amarbel* os dried and burnt near the injured animals (Una, Himachal Pradesh) (Kaur, 1998).

In case of throat soar, green dal is fed to animals 1-2 days thrice a day (Singh, 1998 a). In some places *Adhlatoda vasica* and *Vitex negundo* leaves and sorn are boiled together and fed to animals (Devi, 1998 a) still others paste the Halon (*Lepidum sativum*) leaves on the neck of animals (Singh, 1998 b). Unripe bittergourd alongwith a chapati fed to the animals also relieves it from pain (Una, Himachal Pradesh) (Lal, 1998).

- In muscle pains animals are bathed in hot water or warm *Aak* leaves are put on their back (Gujrat) (Patel, 1999).

- Smoke the animals with shisham sawdust and paste them with garlic (100 g) 2-3 times a day (Bhavnagar, Gujar) in case of viral fever (Bhurya, 1999).

- In case of mouth and foot disease in goats Assam people wash the feet with potash solution and put mobil oil on them (Barua, 1999 c).

In Southern Gujrat mix *Ubhra* (*Ficus racimosa*) bark with banana stem juice and sieve it. This is fed to the cattle suffering from pneumonia followed by 250 ml
groundnut oil. The cattle recoup after 2-3 days. this mixture gives stickiness to the intestine. The farmers of Bhalor district give the calves of nagor (Vitex negundo) 200-250 g mixed with fodder to the pneumatic cattle (Jeevanbhai, 1997).

The farmers of Panchmahal mix the dry bark of Khakhro (Buta monosperma), Mahua (Mahua latfolla) and Khait (Acacia catechu) in equal quantities. The 200 g of the ground powder is then mixed with water, boiled and kept overnight to cool. In the morning it is sieved and fed to pneumatic cattle twice a day for two days (Singh and Ram, 1997).

The villagers in Sabarkantha (Gujrat) collect the earthworms, dry them in sun and powder them. When the calves have stomach problem or the parasites are doubted in their intestine, a spoonfull of this powder is fed to them in 200 ml milk. The parasites come out with the feces (Chauhan, 1997). The intestinal parasites are also killed by feeding calves 500 ml Lassi (curd milk) mixed with 50 g salt for a week or feeding them with white onion 250 g mixed with sesame leaves.

Against foot and mouth disease of cattle in Andhra Pradesh, farmers feed the cattle with Asgandh (Withania cogulan) 500 g powdered roots for 2-3 days or the Dhak (Buta monosperma) 50 g dry bark for 2-3 days once a day (Samappa, 1999). Some also feed the cattle once with one kg fenugreek leaves and three bananas (Safruddin, 1999). The coriander leaves along with three bananas fed to cattle for three days once a day also relieve them of the disease (Ismailappa, 1999). Few Nirgandi leaves (Vitex negundo), 50 g dry coconut powder, three bananas with one kg fenugreek leaves fed once removes the disease. (Rubamma, 1999). The other method use there is feeding of Turvar leaves (Cacia oriculata) juice to the diseased cattle (Tukamma, 1999).

In Una (Himachal Pradesh) people make the diseased animals to move on hot sand, use turmeric powder and mustard oil paste on feet (Ram, 1999), use mustard oil and then spray phenyl mobi oil on feet (Chand, 1999 a), use resin of pine (Pinus roxburghii) on feet or warm mustard oil mixed with chilli powder (Devi, 1999).

According to Khattana (1999) in Bhargava district (Gujrat) some farmers smoke the diseased animals with the porcupine needles. In Gujrat some farmers make the diseased cattle to move on hot sand and then put neem leaf extract of feet (Bhagwanbhai, 1999). In Dang (Gujrat), farmers cook the Kusum fruits in fire. The oil is collected from them and 50-100 ml of it is used on mouth and feet of the animals. Nothing is given to the animal for 1-2 hours. This gives 70 per cent relief (Sonubhai, 1999).
In Kangra (Himachal Pradesh), in case of fever and backache the animal message is done using Baryan (Acros calamus) dried powdered roots mixed with black salt (Devi and Kumari, 1999).

In case of animal poisoning Basuti leaves (Adhatoda vasika) leaves are boiled and warmth given to animals (Sharma 1999 b). The turmeric powder is also fed after boiling to animals or tied at the problematic portion (Kangra, Himachal Pradesh) (Sharma, 1999a).

In Champavat (Uttarakhand) to kill intestinal pests in animals, farmers feed calves with 2-4 garlic cloves, 1-2 onion tubers ground in 25-50 g mustard oil. The pests come out with dung (Rathore, 1999 a).

In Uttarakhand farmers use Rethu (Acacia rugata) peeled seeds paste made in water against the leech by putting the paste in animal nose and keeping the animal in sunlight. Leech comes out within half an hour (Rawat, 1999).

The farmers of Timchi (Tamilnadu) put betel leaf soaked in oil on the tongue of animal having pimples on tongue and throat. They give leaf extract of Mahua (Mahua longifolia) to pneumonic animals. Dhatura fruits are also given to feveriing animals (Narayanan, 1999 a).

The tribes of Sambalpani (Gujrat) hang the Dhak (Bute monosperma) branches on the door and boil the bark of the tree in water which is fed to animals twice a day (1.5 L to adults and 1 L to infants). The animals recover within 15 days (Anon, 1999a). In Dharampuri (Tamilnadu), the farmers smoke the animals with Amaltas (Casua fistula) leaves and keep the diseased animals in isolation (Kanappa, 1999).

In Gandhinagar (Gujrat), farmers smoke the animals with the paws of horses Abhubhai, 1999) whereas in kaclh (Gujrat) feed the animals with sorghum chapati soaked with excess of pure ghee for 3-4 days (Gokulbhai, 1999). Some also give cooking oil and 2-3 onion bulbs twice a day. However in Megharaj (Gujrat) the farmers soak Gugal and Dhak bark in water for sometime so that the bark becomes soft. This is powdered and feed to animals Arni leaves are powdered and the paste is used on feet (Lalubhai, 1999). In Sundemagare (Gujrat), the tobacco seeds and Kapur mixture is poured on animal feet (Bawalbhai, 1999). In Jamnagar area, the animals are fed with Ajwai seeds (50g), molasses (100 g) and tea powder (25 g) boiled in water (500 ml) and then sieved (Ahar, 1999).
In some areas of Uttar Pradesh separate the cattle having foot and mouth disease. Such cattle are given fodder and water separately. They wash the mouth and feet of the cattle with alum and also make the cattle to move in mud twice a day (Singh, 1991). Some farmers wash the mouth of diseased cattle with babool (Acacia nilotica) bark boiled in water and sieved. This solution is used on feet after mixing with alum (Pal, 1999).

Some farmers mix gum (15-20) with Dhak powder and wash the mouth and feet of cattle for 2-3 days (Udaikishore, 1999). The warm mustard oil or common salt mixed with water massage on feet also gives relief to the cattle (Lal, 1999).

In Tamilnadu, some villagers burn dry fish, turmeric powder and dry neem leaves in the cowsheds against foot and mouth disease (Ayyavu, 1999). In Tirchi village farmers feed them with banana fruits kept overnight in sesame oil. They also keep fish in water and wash the cattle feet with this water (Narayanan, 1999b).

In Bhaduch district (Gujrat), farmers make a hole in the base of an earthen pitcher and put it on a metallic pot in the pit dug in a field so that the half pitcher is above the ground. This pitcher is filled with the bark of Shisham (Dalbergia sissoo) soaked in water. The day cow dung cake is burnt around this pitcher. This results in black liquid from the bark which collects in the metallic pot. This liquid is used to wash the feet of animals suffering from the disease (Vasat, 1999).

In Tanzania, the farmers smear the cow dung on the ticks feeding on the cows/ buffaloes. This kills the ticks. Some farmers take the animals to the rivers where fish eat away the ticks. This is also prevalent in our country (Guromela, 1997).

In Solan (Himachal Pradesh), in case of cold of goats (Bach (Acorus calamus) dried roots are ground and converted to a paste in water which is fed to goats. In case of fever they are given boiled extract of Bana (Vitex negundo) branches and leaves mixed with Banphsha (Viola serpens). The goats ailing from foot and mouth disease are fed with mustard oil boiled with garlic cloves. This oil is poured on animals mouth and nose. Neem extract is used to wash the feet. For cows, buffaloes, the horse dung is spread in the cattle shed. But the scientific base of it is unknown (Chaudhary and Das, 1999).

**Sustained Livestock/Animal Husbandry**

People inhabiting high altitude cold desert areas, through their traditional experiences have identified dazo/dozono, yak/demo, and donkeys as a source of energy.
The males viz. dzomo, yak and donkeys are the desert stalwarts helping the inhabitants in carrying out labour intensive work (ploughing, transportation, etc.) whereas female population-cow (local breed), dzø and demø are the chief milk producing animals. Since most of the livestock is less productive, steps are being taken to improve livestock through selection and cross breeding to enhance quality and quantity of their produce.

The Kinnaurs have developed a self-sustained system based on the resources available in the area which is still practised.

Sheep, goats, local cows, mules, donkeys and crosses of cow and yak (churu) are kept by the farmers in the district primarily as a source of manure. Churu are preferred as they are well adapted to the area and their milk yield is also higher. Cow and goat milk is used in this region. Sheep and goats are a good source of meat and wool besides providing manure for the fields.

* Yak (Fig 26) is an important animal of the cold desert region for it provides milk, meat, hide and wool. Besides being a feast of burden it is also a draught animal. Yak skin is used as a loose robe by local people at high altitudes. Its long hair is made into fly whiskers, ropes and is woven into a rough cloth meant to cover tents. Bones, horns and hooves of the animal are used for manurial purpose.

In the cold deserts, a mentioned earlier, where the yak cannot travel, sheep and goats are employed for the transportation of food and other items of daily need.

The cross of yak and cow (churu) is not totally domesticated. In upper Kinnaur, to make their use in ploughing, the noses are pierced and rings are put through them, a person walks ahead holding their nose rings to guide them in the desired directions.

The limitations of such animal husbandry practices are rooted in the adverse effects on grazing lands, from increasing livestock population and the introduction of high yielding breeds which require higher fodder intake and greater care.

**Hay/Dry Grass Storage in Fields**

A practice specific to upper Kinnaur and also operational in other regions involves cutting, drying and subsequent storing of grass from the natural grasslands (ghasni) at considerable moisture level in the form of ghoars. The grass is cut after the dew has evaporated and the sheaths are left in the form of bundles (pools) to dry in the field itself by different methods so that its green colour and leaf characters are conserved. To achieve these characters it is dried under shade, along walls, fences, on trees or on roofs.
Fig 26. Yak - a multipurpose animal

Fig 27. Wool combing device (Kangroo)

Fig 28. Combing the sheep wool with "Kangroo"
Fig 29. Combing sheep wool with "Phanani"

Fig 30. A Bamboo basket (Kamoli)

Fig 32. A spindle - "takli"
Fig 31. A woman spinning the wool for making woollen thread from combed wool pack (Fa)

Fig 33. Combing and spinning sheep wool
This dry grass which is lea  y is known as 'hay' and is used for feeding animals during lean periods i.e. winter and summer months. After drying the grass, it is stored either in a circular or elongated form as per the quantity of hay. The base is first constructed with stones arranged in a circle. The first layer consists of poor quality grass or thorny bushes. The bundles of grasses are then so arranged and placed that their weight completely falls on one another while maintaining the circular or elongated shape. In the case of circular shape, the width is more at the base which starts decreasing from the middle of the structure called 'talent' and ultimately it takes the shape of circular pyramid. Earlier a cloth made from yak’s hair called 'Thobi' was used to cover it, but now a layer of green thorny bushes or poor quality long grass is used as a cover along with wheat or raijash straw. Stone or heavy wood logs are used for pressing and holding the ghor in place.

This practice affords the advantage of maintaining the quality of grass by protecting it from snow and rain. Pressure of stones and wooden logs on the upper layers provides protection against strong winds. During winter months, the required quantity of grass is removed from the ghor periodically which remains completely dry and warm and is therefore relished by the livestock.

In most cases the grass is harvested when it is completely dry and devoid of leaves and is consequently poor both in quality and quantity.

Traditional Wool Combing and Spinning

In temperate Himalayas, farmers use large sized shearer/scissor for shearing wool from goats and sheep. The sheared wool is combed and made smooth either with a special comb called Kangoo (Fig 27 and 28) or with a special arrow like device called "Phanai" (Fig 29). The combed wool is stored in a small bamboo basket (Kamoli; Fig 30) in the form of a small pack (Fa, Fig 31). These small woollen packs (Fa) are used for spinning a thread with a special spindle device known as Taklu (Fig 32 and 33). These woollen threads are used for making woollen fabrics like blankets (Pattu double and single), long woollen cloth Lahanga/Pattee), dark black woollen cord (dora) and shawls which are generally woven by Gaddies on indigenous handlooms (Fig 34).

• The Gaddies wear a typical dress which suits the physical and climatic requirements of the lifestyle and their terrain. The sheperds, during migration, keep new born lambs and kids under their chola protect them against the severe climate. The approximate weight of the chola is 5-6 kgs.

• Dora is the most important part of the dress of Gaddies and is used irrespective
TRADITIONAL PLOUGHING EMPLOYING YAKS

INDIGENOUS PLOUGH

LOCAL LIQUOR DISTILLATION

FARMERS WITH BAG MADE OF GOAT SKIN
of the age or sex. It is tied round the waist over the chola which aids them in supporting the lower back while carrying heavy loads on the back. It is also used as a pillow, especially while travelling.

FOLK AGRONOMY

The art of crop production which is as old as civilization itself and its essential features have remained largely unchanged over the ages. Productivity in cold deserts in Himachal Pradesh, as elsewhere, is centered around crops and animal husbandry. People, through the ages, have developed need based and location specific indigenous technologies for enhancing productivity. The concept of quality seed is well known and agronomic practices are standardised for tiding up the limited cropping period. Rotation of crops, particularly with legumes, is adopted for improving soil fertility. Sowing and harvesting schedules are steeped in cultural heritage. Adequate care is taken to protect crops from both pre-and post harvest losses.

Indigenous technologies with regard to mixed cropping, rotation of crops, agronomic practices, use of indigenous genetic seed sources, seed selection, harvesting, threshing, storage, etc., are summarised in the ensuing pages.

Prioritization of Crop Sowing

In the cold deserts crop sowing in one season is linked with the ripening period of crops of the previous season. Wheat, barley, pea and buckwheat cultivation follow in sequence. In case of fragmented land holdings, sowing is prioritized according to altitudinal zonation. This helps to tide over the rather limited growing period by synchronising harvesting, threshing and storage before the onset of winter. In this manner scarcity of labour is also coped with effective and efficient crop management. The individual farmer is thus able to attend to his fragmented land holdings which are spaced over varying altitudes.

Mixed Cropping

Cultivation of maize with millets, beans or pulses are the constituent crops in mixed cropping. In addition, leguminous pulses are also cultivated on the available land, along the edges of plots. Mixed cropping affords the advantages of crop diversification along with value addition. It provides a shield against the event of particular crop damage. It also maintains soil fertility and productivity besides conserving soil.

Rotational Farming

At the relatively lower altitudes rotational farming is traditionally practised for
enhanced production. Barley, pea and wheat constitute the common rotation. This practice balances soil fertility and avoids spread of diseases from one crop to another. Pea cultivation after barley crop fixes atmospheric nitrogen. Soil compactness induced by barley cultivation also serves as a check against wind erosion.

**Crop rotation and double cropping**

This practice is specific to remote locations. Rotation starts with barley in the first year, and buckwheat during the second year. The rotation sequence is governed by the quantity of available manure. Ordinarily one-third of the total holding is thoroughly manured during the year for barley cultivation. In the following year the soil retains a good deal of fertility for buckwheat for which no additional manure is added. In the third year the same field wheat is sown. The remaining two thirds of the holdings are similarly treated in succession. Barley requires heavy doses of organic manure for better crop harvest. However, the organic content of the soil after the harvesting of barley is sufficient to raise a good produce of millets followed by wheat. This helps to meet the challenges of limited availability of organic manure for successful management of soil fertility levels.

**Crop rotation and practice of fallow lands**

Cultivation of wheat or barley is followed by a fallow period during winter. Millet and maize or buckwheat are planted in the following year. Usually maize is followed by wheat; buckwheat or mash is followed by wheat after maize. Where maize is not cultivated, wheat and barley crops are generally raised (on unirrigated fields) in the following spring season. This is replaced by buckwheat under irrigated situations.

This practice of crop rotation helps in maintaining soil productivity. Leguminous crops fix nitrogen. The growing of different crops viz., maize, wheat, barley and millets conserves soil due to their different root systems which extract nutrients from different layers of the soil. This also helps in crop diversification and control of any soil borne or crop residue carrying diseases/insect pests. The practice of keeping lands fallow preserves and restores soil fertility. The altitudinal gradation in land holdings is also harnessed through crop rotation.

In Banskantha, gujrat farmers of Machla rotate the crops in the sequence of maize-paddy and black gram-Arand-groundnut. Maize has deep roots, paddy and black gram shallow roots and Arand has deep roots which reduces the pressure on soil nutrients. Groundnut and black gram fix nitrogen in the soil (Kalabhat, 1999).
Fig 34. A group of tribal women in their traditional wool dresses

Fig 35. Crop threshing employing animals
Crop Threshing Employing Animals

Animals, particularly dzos, are used for threshing crops by trampling, in the cold deserts. A large circle of packed earth (about 10m in diameter) forms the threshing floor. A number of animals are tied in a line to a central pole. Dzos once stirred, continuously circle the central pole for hours without showing any fatigue (Fig 35). Often there is a combination of animals, as many as twelve, with the dzos forming the inner circle while horses and donkeys circle along the outer edge. Threshing is accompanied by singing. To prevent the soiling of the grain by animal dung, a container is used for collecting the dung before it falls on the ground.

Even animals (commonly churu) are used for the threshing of crops (wheat/barley). After harvesting of crops from August to September, the same are left to dry in a common courtyard (Khatian). After complete drying, it is spread in circular heap formed around a central pole. Two pairs of churu are used for trampling the dried crop. However, it is also observed in the Tod Valley that in order to increase the weight of churu a weight of 30-40 kg (made of wooden and husk straw, sealed in gunny bags) is tied to it. Then the churu tramples the crop for one hour after which the crop is turned over so that it may be trampled upon completely. This process of turning the crop over, continues for 5-6 hours. After which the crushed material is collected and piled into a heap. The grain is subsequently stored in houses mainly for home consumption.

Threshing by animals is preferred by farmers as mechanical threshers are not available in these remote areas and are also costly. Additionally, the general feeling is that wheat straw/barley husk crushed by the mechanical thresher is not palatable to cattle stock because it is reduced to a fine texture. Also mechanical threshers crack more grains which is obviously not preferred by the farmers.

Manual Threshing

Threshing is also done by people keeping the crop on the ground and beating with sticks.

Use of Yak and Bullocks for Ploughing

Yak and bullocks are commonly used for ploughing the crop fields. A lady guides the yak via a rope which is tied around its neck to follow a particular furrow and behind the yak, a male does the ploughing through the plough tied to the yoke of the yak (Fig 36 a).

In temperate region a pair of bullocks, tied with a common yoke and a plough in between, are used for ploughing. These bullocks are normally small sized and well suited to plough the narrow field strips of hill tract (Fig 36 b).
Furrow as an Indicator of Sown Field

After the seed has been sown and the field levelled with subaga, a furrow is drawn in the middle of the field. This furrow acts as an indicator of sown field so as to keep it undisturbed from human and other animal activities (Fig 37 a & b).

Uniform Seed Broadcasting and Appropriate Seed Rate

Broadcasting is performed by girls in cold desert areas. One handful of seed is uniformly broadcast in three to four equal lots. The quantity of seeds thrown in each lot is determined by the distance of furrows made during ploughing. For verification of properly spaced broadcasting a handful of soil is picked up at random from any part of the field and if in each pick there are seven seeds it is indicative of proper broadcasting. Incidentally, this "seven seeds test" roughly coincides with scientifically recommended seed spacing.

For wheat / barley, an expert from the family casts the seeds with such precision that each pick will contain seven seeds, thus distributing a measured quantity of seeds. After casting the seeds ploughing is done using a local plough. This operation covers the seeds in soil upto a depth equal to two times the diameter of the seed.

Broadcasting as practised, is advantageous when compared to line sowing since it reduces labour requirement.

Rice Dehusking

Rice dehusking is done by using a wooden pestle and mortar. Usually two ladies perform this function by using the pestle alternatively (Fig 38).

Crushing of Coriander Seeds with Shoe Before Sowing

Coriander seeds in Kinnaur, are crushed by being trampled upon by leather shoes before sowing for better germination. While the exact use of this technique is a subject for research, it appears that this mechanical exercise exerts just the right pressure to break the hard testa without causing any injury to the seed itself, thereby facilitating germination.

Crop Harvesting on Slopy Lands

In West Himalayan cold deserts, crop harvesting is affected by a sickle used in the upstream direction for maximizing biomass. Eight to ten plants held right near the base, are pushed forward and then cut. This method of crop harvesting from bottom to top ensures maximum harvest by reducing wastage through easy handling and consequently saving labour.
Fig 36a. "Yaks" for ploughing

Fig 36b. Bullocks for ploughing

Fig 37a. Laying plough furrow as sign of the sown field

Fig 37b. Laying plough furrow as sign of the sown field
Seed Selection for Higher Productivity

Seeds for future cultivation are collected from selected plots manifesting vigour, early maturity, disease resistance and higher productivity. After three to four years, the seed source is shifted to other villages without diluting the selection criteria. This practice of collecting seeds from different villages after every three to four years is a check against inbreeding which otherwise may induce low productivity.

People in Kerala, select the healthy seeded paddy plants in the field on which the attack of insects and diseases is minimum. The weeds near to them should also be minimum. They collect the healthy seeds, sun dry them to avoid pest and disease attack, allow the frost to fall on them (to soften the more hardened seeds), put them in a pitcher covering them with neem leaves at the bottom and at the top (Abraham, 1997).

The seed germination test is done before sowing. For this coconut bowl is filled with water and paddy seed is sown in it. To enhance germination the seed is allowed to germinate before sowing. The bag filled with seed is kept in water and pressed using stones/bricks. The seeds germinate within 2-3 days which are broadcast in the field (Abraham, 1997).

In Sagar (Karnataka) watermelon seeds are soaked in milk and water solution one day before sowing to enhance yield. In Sirsi bittergourd seeds are soaked in milk for a day (Goda and Prabhakar, 1998).

Minimum Tillage (Mechanical and Biological Practices for Soil Management)

Wheat and barley are sown directly after a single ploughing. No second ploughing is undertaken. Sometimes, if in areas where upland paddy is sown when dry season prevails at the time of harvest, wheat is sown immediately after the harvest. No preparatory tillage is undertaken. Fields are left fallow in rotation. Soil management practices like minimum tillage/only one conventional tillage (ploughing), ensures least disturbance to the soil, thereby reducing soil loss through surface run-off. The nutrient losses are also curtailed. Consequently an improvement in the soil's physical properties e.g. water holding capacity, chemical properties like nutrient availability and microbial properties are affected, by leaving the fields fallow during rotation, there is a consequent improvement in soil fertility due to absence of erosion and crop nutrient uptake.

Dividing the Fields into Sub-plots

Fields are divided into smaller sub-plots for irrigation, otherwise land being sandy, water percolates immediately through one large plot. To stop water at each level sub-plots are made on sloping land. The same practice is also observed during vegetable cultivation.
Ploughing with the Indigenous (Desi) Plough

Use of the indigenous plough is still prevalent in the Spiti valley. During the month of April, farm yard manure is first spread uniformly by the women and then the fields are ploughed (Fig 36 a & b).

Local farmers confirm that the Desi plough does not bring the bottom soil to top and vice-versa, by virtue of this the top humus layer does not get turned under. This layer of humus also acts as mulch thereby optimizing the use of irrigation water.

Landuse for Optimum Resource Management

In upper Kinnaur wheat, barley, lintil etc. are sown in the post monsoon season while, millets, potato, maize and leguminous crops are sown in the monsoon season. Rotation is operationalised in such a way that no exhaustive crop is repeated in the following year. A two year rotation is thought to be necessary for optimum resource (land) use.

The cattle are grazed by one man who belongs to the lower caste. Food is provided to him by the villagers for the service rendered. Sheep are grazed together. This practice has the advantage of providing employment to one with no regular source of income and it is, at the same time, labour saving.

Extraction of fibre and seeds from Bhang (Cannabis)

Bhang (Cannabis) leaves are used for extracting narcotics (Fig 39 a, b & c) which is very addictive and its cultivation is also illegal. After maturation the harvested crop is set aside to dry. After drying, the seeds are collected and the fibre is separated from the stems and branches. Its fibre, being stronger than jute, is used for making ropes of varying thickness. The rope making process is depicted in (Figs 40 a, b & c). Besides its acknowledged strength, it is one of the cheapest materials for rope making.

ITK for Vegetable Cultivation

Root spreading for surface feeding in vegetable plantation

A small wooden structure is used for digging the soil facilitating the horizontal spread of roots in cabbage and other vegetable crops thereby increasing production. This practice facilitates enhanced moisture / nutrient uptake along with the removal of weeds. The wooden structure protects roots from mechanical damage which could result from an iron implement.
Fig 38. Traditional rice dehusking

Fig 39a. Narcotic extraction from Cannabis

Fig 39b. Cannabis smoking

Fig 39c. Cannabis smoking
Fig 40a.  Fibre extraction from cannabis

Fig 40b.  Rope making from cannabis fibre

Fig 40c.  Rope made of cannabis fibre

Fig 41.  Chopping of potato seed for sowing
Osmoconditioning of pea seeds

The garden pea is a significant commercial crop. The crop sown in the month of October-November, before it snows, shows relatively better early germination when compared with seeds sown in the month of March / April. Sowing in winter allows adequate time for the physiological activities to occur within the seed, resulting in an early crop.

The early germination may also be attributed to a better hydrothermal regime during February-March for the crop sown in the month of October-November. The additional advantage is that the produce can be transported to the plains to secure excellent economic returns.

Cropping pattern

In Kinnaur monocropping pattern prevails. The crops like potatoes and peas are sown in the month of April and harvested during September to October. The poor fertility status of soils require that such soils should not be over utilized.

Instead of sowing whole potato tubers, it is chopped into two to three pieces and each chopped piece must have an eye, to ensure seedling after germination (Fig 41)

Home/kitchen garden

Garlic, dhoomu (wild onion) and coriander were sown in kitchen gardens. A perennial wild plant locally known as jarga was also a permanent feature of the kitchen garden.

Leaves of garlic, dhoomu, coriander and jarga are used as spices.

Mahotar/dhingri/guchhi (mushroom)

Generally, during the rainy season prolific growth of dhingri is observed on termantoria. It is also observed that during lightening/ thundering of clouds mahotar abounds on grasslands and guchhi (mushroom) sprouts in deodar forests. Guchhi (mushroom) besides being highly nutritive and tasty it fetches a handsome price. Collecting it from the wild requires trained eyes and considerable expertise.

ITK for Horticulture Crops

Localised green house conditions in grape cultivation

Grapes are cultivated by regulating the temperature of basins using local stone (called bricks), grasses, warm clothes, gunney bags or wooden baskets. Grapes are grown
only in sunny niches. Pits are filled with locally found stone, grasses and soil, the white brick pieces help in warming the otherwise cool sandy soils in the basin. Grape vines are covered with warm clothes or gunny bags or wooden baskets to shield them against the cold and animals attacks, especially during the initial one to two years.

This method indicates the use of localized green house conditions for grape cultivation and subsequent fruit sweetening.

Apricot grafting

In the Nubra valley of Ladakh, apricot grafting (seedlings) is commonly practised. Scions (sweet types) are grafted over bitter forms of wild apricot. This job is carried out by three to four experts (free of charge) in a village. Local techniques are known as Kalam and Dambu. In Kalam half lamina along with the petiole is inserted into the peeled part of the stock and the removed bark is then used to secure the union. A two to three years old scion is preferred. Dambu is practiced on one year old seedlings. In this case a cut is made in the bark at the point of bud with a deliberate slow rotatory movement and the entire piece of cylindrical bark is removed much like the cap of a pen. It is then rewrapped and secured so that the petiole region of the scion is properly united with the stock. Protection of two to three vital veins in the petiole region is regarded as essential for the success of this graft.

The use of peeled off bark as a piece in Kalam and Dambu displays local wisdom for providing moisture to the grafted union. The use of the half leaf lamina is a check against possible damage to the union due to strong blowing wind, a common phenomenon in the region. Protection of specific veins indicates a knowledge of the nutritional linkage between scion and stock.

Enhancing soil fertility

Animal bones are buried in the basin area of the plants. The animal bones improve soil fertility by adding phosphorus to soil.

Fruiting in apple

It is believed that if an old leather shoe is hung on the non-bearing apple tree, the tree starts fruiting.

Fruiting in walnut

A hole is bored into the trunk of the walnut tree (s) upto the hollow pith region. This results in oozing out of extra water present in this region and the tree starts bearing fruits because the water present in the pith retards the movement of nutrients from the
FENCE MADE OF STONES AND THORNS

APPLE PRUNING

GRASS USED AS MULCH

LOCAL METHOD OF APPLE GRADING
roots to the upper region. Additionally, the branches of the non-bearing trees are pruned for bringing it to bear fruits.

**PLANT PROTECTION PRACTICES**

In recent years, the large scale application of pesticides, primarily insecticides, has made cultivation on some mountain crops and fruits difficult due to the harm brought to bear upon the bio-environment by large scale destruction of natural bio-enemies causing pest resurgence, development of resistance to pesticides and consequent secondary pest outbreaks. Perhaps the only solution to this problem at hand lies in the adoption of eco-friendly approaches which are not destructive to natural enemies but gradually remove sizeable proportions of pest populations and tend to keep their populations in check. Physical, (devices and procedures used to change physical environment of pest populations), and mechanical (mitigating pest populations by cultural practices) methods of pest control are the oldest of all such insect control methods. These are rooted in simple practices that man, as a farmer, has learnt from his long and close association with pests. These aid him in reducing pest populations to low levels. These include both direct and/or indirect measures which may be preventive or corrective in nature but are essentially slow acting, often ecofriendly, cost effective and compatible with other methods of pest control. These characteristics make them amenable to blend better with integrated pest management practices (IPM) even though they do not bring about an immediate or drastic reduction in pest populations. Even the modern concept of pest control does not emphasize the outright eradication of pests but focuses on maintaining their populations at levels which do not cause economic losses. Some of the indigenous methods of IPM include:

**Ploughing, Hoeing and Basin Preparation**

Cultural practices like ploughing, hoeing and basin preparation influence directly, the survival of soil inhabiting pests. These routine agricultural operations expose soil inhabiting insect pests and other arthropods and nematodes to harsh weather and to natural predators. Insects are most vulnerable when in the pupal stage and most insect-pest pupate in the soil which furnishes a protective habitat. Birds like the king crow, the myna, the starling etc. pick up the exposed pupae following these cultural operations. Some insects e.g. grasshoppers, crickets, mole-cricket and borers lay their eggs in the upper layers of the soil. Their eggs are exposed during soil preparation and subsequently desiccate. Many insects like cutworms, grubs of the root borer and white grubs which feed on the root system of plants are also exposed to the vagaries of the elements during basin preparation and hoeing. Deep ploughing carried out during winter helps in reducing
the overwintering populations of several pests.

The afore mentioned cultural operations are performed manually in the hills using locally made tools and implements discussed ahead.

Besides dislodging the pests from their protective habitat and subjecting them to unfavourable conditions for survival, these scientifically tempered cultural practices also improve aeration of the soil and facilitate proper percolation of water into the soil.

However, the degree of success of these operations is related directly to the presence of natural predators in adequate numbers and the synchronization of these operations with the vulnerable stages of the pest's life cycle.

Hand Picking of Pests

Hand picking of pests and their destruction is another time tested method of pest control. Right from picking lice from human hair, clothes and even animals to the manual separation of pests from stored grain. This method can prove effective in curtailing pestilence on some crops. Insects which lay eggs in conspicuous and easily eliminated masses, e.g. tobacco caterpillar, gypsy moth, hairy caterpillar, sugarcane top borer, epilachna beetle, etc. can be easily eliminated. Early instar larvae of such insects often feed in congregations and later disperse on to the entire plant/ tree and in the field, making control at best, difficult.

Hand picking demands alertness, patience and keen observation. The collected pests are destroyed by immersing them in kerosene water or by deep burying. Nocturnal insects responding positively to light, e.g. defoliating beetles, moths of Bihar hairy caterpillars, tomato fruit borer, tobacco, caterpillars, and cerambycidae beetles etc. are collected, using light source or by trapping them in a light-trap and are subsequently destroyed.

However, it is a labour intensive and time consuming process. Knowledge of egg laying behaviour, location of eggs and larvae on infested crop is essential. Hence, only a well trained person would prove effective.

Cow-Dung and Clay Mixture

The practice of applying a thin paste made of cowdung, clay and cow urin, as a disinfectant, on the floor of mud (kutcha) houses in rural areas is an age old practice. Similarly, the application of a paste, of good consistency, to treat wounds and injured limbs of fruit trees has been in vogue, in villages, since long. Such a paste is also applied to pruned twigs/limbs.
A fine slurry is prepared by thorough mixing of the clay, cowdung and cow urine in a container. The paste is then applied manually using bare hands or a locally made brush.

COWDUNG AND COW URINE possess complex degrading substances and may possess anti-bacterial properties. Addition of clay results in better adhesion of other constituents to the treated surface. Sealing of wounds/cuts prevents access of pathogens to the otherwise exposed surface. To some extent, the already present pathogen is also dealt by using the applied paste. Pruned ends of twigs and cuts are also favourable spots for the settlement and establishment of woolly (apple) aphid on apple trees. Covering such sites with the cowdung paste hastens healing and prevents aphid settlement. The paste is also used for the treatment of cankered limbs of the trees. The entire affected region is removed by a disinfected knife and is then pasted. As is evident, the application of the paste is a laborious procedure and proper sealing of the injured region is required. Sometimes, it does not prove to be an effective method for the treatment of canker.

Pruning of Fruit Trees

Pruning and training of fruit trees is an important practice performed during the dormant season to create a proper frame and provide symmetry to the tree and ensure proper and balanced growth in the ensuing season. Set procedures of pruning are followed by using secateurs, knives, pruning saw, etc. Some inconspicuous pests which hibernate as eggs, nymphs (e.g. some aphids, leaf hoppers, etc.) in limited numbers are automatically removed along with pruned branches/twigs thereby mitigating the severity of their attack in the next season. Further, pruning of old, damaged and weak portion of the tree encourage new growth which is healthier and stronger.

Thus, pruning aids pest control as it releases overwintering population, improves general health of the tree and helps in maintaining a balanced foliage distribution with proper aeration and sunlight penetration. Pruned plants usually have lesser pest infestation and do not easily succumb to pest attacks.

However, since pruning is both an art and a skill it demands that the pruner possess basic knowledge of overwintering behaviour and sites of pests to deliver maximum benefit from this mechanical method of pest control.

Use of Wood Ash on and Around Vegetable Crops

Fruit wood is a major source of energy in the hills, consequently, wood ash is available in plenty. It is used to wash and clean utensils as well as clothes in many areas of Himachal Pradesh. It is a common practice to sprinkle wood ash on vegetable crops,
especially growing in kitchen garden and to spread it around plants to ward off pests and to enhance nutrient status of the soil. To achieve this a thick layer of ash is spread on the soil around plants and it is also sprinkled on foliage to protect it against a variety of pests. This is because it is a source of phosphorus for plants and it also acts as a physical poison usually causing abrasion of epicuticular waxes and thus exposing pests to death through dehydration. It also interferes in the chemical signals emanating from the host plants thus obstructing the initial host location by pests. The treated foliage further becomes unpalatable for foliage feeders like cutworms, caterpillars, grasshoppers, etc. But since ash provides only temporary protection against pests, insecticides which have quick knock down effect have replaced the use of wood ash today.

Beating Drums and Using Domestic Dogs for Combating the Menace of Birds and Monkeys

Birds and monkeys are commonly found vertebrate pests which cause tremendous damage to some ripening crops and fruits. Most bird species are protected by law and monkeys can also not be killed due to religious sentiments. Alternately, the practice of driving them away by beating drums and using well trained dogs has been used since long. Locust swarms are also warded off by the beating of drums. Today, one or two persons are engaged in these activities during periods of fruiting/crop maturity (along with one or two trained dogs Gaddi or Alsation). While the noise created by the beating of drums and barking of dogs scares birds and monkeys, it requires the employment of regular labourers for constant vigil (Also monkeys and birds may become used to these practices).

Kerosene Oil for Killing Borers

Shoot and stem borers bore and riddle the twigs, branches and even the main trunk of fruit trees and push out faecal matter and frass through an exit hole (Fig 42). Farmers have been using kerosene oil to kill these tissue borers using a flexible metallic wire which is inserted through the hole made by the borer into the gallery to clean it. Then a small bung made of cloth soaked in kerosene oil is inserted into the hole and finally, it is plugged using a paste of cowdung and clay. The insertion of the metallic wire into the gallery causes physical injury to the larvae which are destroyed in the process. The oil vapour emanating gradually from the cloth hung fill the closed gallery, suffocating the pests and ultimately the larvae die. The death of the borer is indicated by unopened plugged hole. The drawback of this practice is that kerosene vapours act slowly and this treatment is not a sure and definite method to annihilate the borer. Farmers now prefer to use quick acting insecticides for assured results.
Fig 42. Applying kerosene for insect borer attack

Fig 43. Sling and Karban (Gulel) for scaring birds and stray animals

Fig 44. Sling and Karban for scaring stray animals

Fig 45a. Wall hive (inside view)

Fig 45b. Wall hive
Use of Traditional Devices (*Sling* and *Karban*) for Searing Birds and Stray Animals

In many regions the *Sling* (*Gulel*) and the *Karban* are commonly used for scaring away birds and stray animal for the protection of crops such as maize, fruits and vegetables. (Fig 43 and 44).

**Use of Walnut Leaves Against Pests in Stored Grains**

It is an old practice to use walnut leaves as a protection for both grain and clothes against insect damage. To achieve protection a layer of leaves of walnut is spread over grain stored in gunny bags. Likewise, shade dried leaves of sweetflag are powdered and put over grain stored in gunny bags to protect it from damage due to stored grain pests.

Walnut leaves are astringents and the aqueous extract of fresh leaves possesses bactericidal action while mature leaves contain 9-11 per cent tannin. Tannins are known to act as feeding deterrents. In some cases *Artemisia* leaves are also used.

**Indigenous Beekeeping Practices**

Rich indigenous knowledge of beekeeping in a variety of hives such as wall cavities, hollowed logs, skeps etc. served to preserve this heritage. These indigenous hives resemble closely the natural nesting sites of the native honey bee (*Apis cerana*). Swarms of feral populations of this bee descend to colonize these nests.

The wall hive is a cavity left in the wall when the house is under construction; it is located at a height of about 150 cm from the floor in kitchens, store rooms, living rooms and/or sheds; the wall hive has an entrance hole of about 2 cm diameter towards the outside; on the inside it is conformed usually with a plant of wood plastered with mud. A swarm of *Apis cerana* descends naturally and settles in this hive making parallel combs. The wall hive is opened only to harvest the honey and never otherwise (Fig 45 a & b).

The *Apis cerana* bee's habit of nesting in natural dark and protected cavities makes the wall hive an ideal home for the swarming bees to descend and colonize. The location of the wall hive at a height in farm houses keeps it away from any disturbance due to activities of the farm's habitants. Human and animal habitation of the farm house, however, provides a relatively constant temperature. Since microclimate of the hive interior is not easily influenced by sudden outside changes, the bees have to spend less energy towards temperature regulation. Further the security offered by human habitation adds to the suitability of the wall hive for bees as they are protected against wild animals such as bears and pine martens.
The log hive is a simple structure without any frame and separate chamber. Prepared by the hollowing out of a piece of tree trunk, closing both its ends and boring a small hole of suitable size along its length to serve as an entrance. Both horizontal and vertical log hives are in use. Length of horizontal log hives varies from 60-75 cm and the entrance hole which is 6 mm diameter or of pencil thickness is made in the centre. Open ends are closed with a piece of tin or wooden plank or stone mixed with cowdung and clay. 4-5 strips of old combs (3 cm apart) are fixed at each end before use. The vertical log hive is very similar to the horizontal one except that it is placed in an upright position on a piece of tin or flat stone with 5-6 entrances/holes above the base. The top closed end may have 8-10 holes of 1 cm diameter each, if the super box is to be used (Fig 46 a & b).

Though movable frames can not be used, as such the scientific management of colonies is not possible and only squeezed honey can be extracted. The advantages afforded by this low cost construction makes it amenable to shifting to orchards for pollination and short distance migration can also be taken up.

In Banskantha (Gujrat), farmers dissolve 250 g asafoetida in 2 L water and put 20 kg groundnut seed in it for 12 h to avoid leaf spot disease on the crop (Rangnathbhai, 1999).

The farmers of Amroli (Gujrat) use 250-300 g Dhatura (Dhatura metel) leaves and branches soaked in 1 L water heated to lukewarm stage and sprayed on cotton plants against cotton aphid (Kachadia, 1999).

At grain formation stage in paddy, aphid attack is increased on the crop. In Kheda district (Gujrat) farmers grow Aak (Calotropis gigantea) on the sides of the field. The aphid do not attack the paddy but remain on Aak only (Rathore, 1999 b).

In Tamilnadu (Dindigul district) farmers put 100 g neem powder at 10 cm depth in the roots of any crop thus saving the plants from aphids and white grubs. On citrus/lemon they spray 500 g powder per tree against nematodes. For the control of leaf borer, stem borer and other diseases on sugarcane, 200 g powder is mixed in soil during field preparation. This powder when put near the stems of coffee plants at the rate of 500 g/plant in monsoon enhances the yield and quality of coffee (Muthuswami, 1999).

In Tamilnadu people boil Ghoe Kanwar (Aloe vera), Neem, Tulsi (Ocimum sanctum), Apamarg (Achyranthes aspera) leaves in equal quantity in water. sieve add
Fig 46a. Traditional log bee hive

Fig 46b. Traditional log hive
this solution to water (100 ml/L water) and spray on lemon and tomato crop which stops flower dropping (Girisari, 1999).

In Banskantha (Gujrat) use juice of tamarind and Mahua (500 ml/15 L water) against pink ball worm and spotted ball worm in cotton (Kodari, 1999).

In paddy farmers (Assam) soak kute rope in kerosene oil. Two persons hold it at two ends and move across the field touching the crop to save it from army worm and other insects. To save the crop from stem borer flood the paddy field with water, sprinkle goat dung on the bunds, spread neem leaves in the field or spread lemon pieces or Mankunda (Alocasia indica) plant pieces in the field (Barua, 1999b).

The farmers of Hubli (Karnataka) mix the plant extract of Bhang (Cannabis sativa) with banyan (Ficus spp.) latex and put it in the holes made by Rhinoceros beetle on coconut trees (Shivshankar, 1996).

Control of pests in paddy

In Kerala the paddy growers use asafoetida and cow urine for the control of aphids. They powder the asafoetida, mix it with cow urine and spray on the crop. Similarly, asafoetida, garlic and chillies are mixed with water and sprayed. They also use tobacco, urine or cow urine mixed with soap against many harmful insects (Abraham, 1997).

In Bhavnagar (Gujrat) farmers use Agave americana leaves boiled in water (200 ml extract/15 L water) against cotton larvae (Aparna, 1997).

Against brown hoppers and stem borers on paddy, the small pieces of Makabuku (Tinospora rampi) are macerated in water and sprayed on the crop (Philippines). Some farmers also add onion, turmeric and red chillies to it (Lamdang, 1999).

In Tamilnadu people save paddy, chillie and Jasmine crops from sucking insects using a solution formed from neem oil, cowdung and sand. One litre neem oil, mixed with 3 kg sand and 3 kg cowdung is put in a wet bag which is stored in a dark room for 3 days. On fourth day 150 L water is mixed to it and sprayed on the crops (Mani, 1999).

In Kanyakumari (Tamilnadu) use neem cake powder against paddy leaf eating insects 910 kg powder per acre) (Thavasinarathan, 1999b). People also put lemon slices in paddy fields against collar rot (Selsel, 1999).
In Champavat (Uttarakhan) spray cow urine on cucurbits against pests (Adhikari, 1999).

In Ittawa (UP) farmers put gur or sugar in pits before planting. They continue gur/sugar application afterwards also. This encourages ants and where ants live the termite attack is avoided (Prasad, 1999).

In Uttarakhand, villagers sprinkle cowdung on Rabi crops like wheat and barley against frost and rabbits (Godkori, 1999 b).

In Kargil (J&K) farmers sprinkle cowdung on apricot plants to save them from goats and sheep (Sharma, 1999).

Bih Mih village of Vietnam is situated in the north east of Red River Delta. In spring the migratory birds pass through the area and eat away the small seedlings. The villagers make a number of paper birds and put them in the fields using wooden sticks. The migratory birds avoid sitting at such places (Thi, 1997).

In Assam put Arabi atom in the field at sowing of crops. Mistaking them as snakes the birds avoid to eat away the seeds (Barua, 1999 d).

The glass is ground and mixed with flour to make small pellets which are kept near the rat burrows to control rats (Una, HP) (Ram, 1998).

In Jaipur, to control termites, a pitcher is taken on which holes of 1 cm diameter are made. It is filled with maize cobs and kept in 1 m deep pit. Mud is smeared to the pitcher from all sides. A number of pitchers are put in the fields on which the termite swarm within 3-4 weeks. These pitchers are taken out and burnt using kerosene oil. Few farmers also use dung in place of cobs (Sharma, 1997 a).

The villagers of Sabarkantha (Gujrat) collect dry and green leaves of Eucalyptus and burn them in the morning in the fields of sonf to control aphids. This is done 2-3 times in a month (Parmar, 1997).

To save roses from the attack of termite the farmers of Banskantha (Gujrat) spray Thar (Euphorbia neriophila) latex 50 ml in 10 L water on rose seedlings before rainy season (Vesani, 1997).

COWDUNG IS SPRAYED ON CROPS AGAINST NEELGAI (Una, HP) (Ram, 1998).
In Tamilnadu 5 L cow urine is mixed with 1 L. *Nirgundi* (*Vitex negundo*) leaf extract (30-40 leaves boiled in 10 L water till it remains 1 L). One litre asagoetida liquid (100 g asagoetida dissolved in 10 L water and 1 L is taken from it). The solution is made to 15 L using water which is sprayed on paddy crop against pests and diseases (45 L solution/acre) (Anon, 1998).

To check gram pod borer farmers in Sabarkantha (Gujrat) take out the extract of 5 kg leaves of *Karanj* (*Pongamia pinnata*) and 5 kg branches of *Basuti* (*Adhatoda vasica*) mix it in 10 L water, sieve it, add 1-5 L water to it and spray on gram crop (Wanker, 1998).

In Uttarakhand, farmers put the cowdung cakes in the field in a heap. The heap is covered with soil from all sides except from top and burnt. The ash thus formed is mixed with soil. This gives better vegetable crops (Singh, 1999 a).

In Karnataka, farmers grow mustard along with sorghum to save the farmer from aphids and beetles as these insects prefer mustard than sorghum. Some farmers burn animal bones in the field to control pests (Nagathna, 1999).

In Gujrat, some farmers spray goat milk on chillies, brinjal and black pepper to avoid leaf and fruit drop (Babudiben, 1999).

In West Bengal, to control pests on brinjal and pumpkin, farmers spray a mixture of cowdung ash and kerosene oil (Modal, 1999).

**POSTHARVEST MANAGEMENT OF FOOD CROPS**

Kinnaur manifests diverse agroclimatic conditions varying from wet temperate to dry temperature, cold desert areas, the different types of agricultural crops grown, vary from cereals, pulses, oil seeds, root crops, vegetables to subtropical fruits viz., citrus fruits, grapes, etc. temperature fruits like apple, pear, apricot, peach etc. and nut crops like walnut, almond etc. The methods of handling, packaging, storage and preparation of different products and their subsequent consumption also varies with the wide agroclimatic diversity in the region. Most food products currently available in the market are essentially improvements/refinements of indigenous technical knowledge of postharvest management of food crops. However, there are still a number of traditional postharvest skills, which can be commercially exploited. Some traditional foods/products help to cure ailments and have been used as home remedies, while others are environment friendly and do not cause any health hazards despite their continuous use. This is an effort to document available information on postharvest operations of storage, curing and drying.
Curing Cereals

i) The maize plant along with the stalk is harvested and tied into small bundles called 'pahra'. All bundles from different fields are collected at one place and stacked in an upright position. Upright stacking of maize bundles is called 'Thua' of 'Zhumb'. After a period of one and a half month, the maize cobs are separated individually from the husk (Fig 47 a).

Stacking of maize in the Zhumb for 30-45 days, ensures ripening and it also facilitates the easy separation of cobs from the husk. Curing results from heat and moisture equilization in the grains in the Zhumb. It has also been observed that initially sweet grains, upon complete drying and curing, become tasteless which is attributable to the conversion of sugars to starch, a common phenomenon also observed in pea and maize grains.

ii) Similarly, millet grains called Mandal or Sonk are allowed to ripen partially by stacking them in a heap and covering the heap with tarpoline. This procedure is locally termed Garr Dena.

The preparation of small bundles Phara, Pooli or Poola help in easy handling and quick drying. Stacking bundles in heaps possibly aids heat and moisture regulation thereby resulting in uniform ripening. The creation of moist heat also leads to curing which eases the process of threshing the grains.

Curing of Chilgoza (Pinus geradiana)

In Kinnaur, chilgoza seeds are separated from the cones by collecting the harvested cones at one place and covering them with chilgoza pine needles, leaves and soil. After 15-20 days, the chilgoza cones are cut-open using a sharp edged axe (Rehla), with a gentle strike the seeds are easily separated. The procedure of covering harvested cones with pine needles, leaves and soil possibly help in maintaining desired temperature and humidity inside the heap, which results in the curing of cones.

Cleaning of Grains

i) Winnowing of grain and pulses is a common practice in every home in Himachal. It is performed using a container made of tin, called Shoop or Chhaj. The grains are placed in Chhaj and slow winnowing leads to separation of dirt and husk from the grain. Almost all types of dry grain like wheat, maize, paddy, pulses etc. can be cleaned in this manner (Fig 47 b).

ii) Bulk cleaning of grain is done using a container made up of bamboo sticks called
Fig 47a. Maize curing by stacking (Thua or Zhumb)

Fig 47b. Sun drying of paddy in stack (Kundli)

Fig 48. Winnowing of grains
Panaudi (Fig 48). The dry grain, placed in the Panaudi, are allowed to fall from a height of about 4-5 ft in a thin vertical flow in the path of a cross wind. The lighter dirt particles and husk are blown away and the heavier grain is thus separated as it falls straight to the ground. The use of a fan (mechanical or electrical) greatly accelerates this process of cleaning. This method of cleaning is based on the differences in density of the materials to be separated. The use of modern air separators/ cyclone separators for grain cleaning is based on this principle.

PACKAGING OF FOOD COMMODITIES

Fresh products

Different types of containers are used for packaging food commodities.

In lower areas containers made of bamboo sticks called Ddalh are used in the fields for packing grain, maize cobs, potato, ginger, turmeric etc. and also for carrying the material from the field to the house.

For packing clean grain, pulses and flour etc. the Ddalh is internally lined with cow dung. The Ddalh has a capacity to hold 25-30 kg material. A similar container, small in size, is called Tokra.

In the higher regions, such containers are called Kilta, however, the shape of the container is different from that of the Ddalh and has a greater storage capacity (Fig 65).

The Ddalh is carried on the head while Kilta is carried on the back and is also provided with two large ropes meant for securing it onto the shoulders much like a backpack. Raw material carried in kiltas includes fresh apples, pears, potatoes etc. and even farm yard manure (FYM). Kilta are internally lined with gunny bags to provide a cushion so as to prevent injury to the fresh fruit.

For transporation of culled apples, and vegetables like peas, beans, capsicum, potatoes, ginger etc. to distant places gunny bags are used as the packing material.

Packaging of perishables/delicate crop, like tomatoes, is accomplished in bamboo boxes called Tokra, which are then covered with thin gunny bags on the top (Fig 66).

The shape of the container Ddalh, Kilta or Tokra provides easy carriage of material on human head or back. The structure is easy to clean and dries soon even after washing it with water.
In some parts wooden boxes made up of very thick wood were used to pack and transport apples. The weight of the empty wooden boxes ranges from 20 to 25 kg i.e. the empty weight was invariably more than that of apples, it carried in it. The box was made sturdy to enable its carriage on mule backs to distant distribution points/centres.

**Packing of pickles**

In lower parts of Himachal, pickled products are packed in earthen pots. The earthen pots are sterilized using fumes generated from burning red chillies along with Asafoetida (Heeng) and a little mustard oil. The top of the container is covered with a lid made of wood.

The antimicrobial properties of fumes of red chillies, mustard oil and Asafoetida not only sterilize the containers and result in increasing shelf life of its contents but also has potential for preservation which serves as a replacement to inorganic chemicals. An excess use of inorganic chemicals may pose healthy problems.

**STORAGE OF FOOD COMMODITIES**

**Food grains**

Food grains like maize, wheat and paddy are stored in special structures made of bamboo called Peri or Peru (Fig 49).

Prior to use, these structures are plastered on the inside with a mixture of cow dung and clay. These containers are placed on the ground floor and grain is loaded into them from a hole made on the roof of the first floor called Bauh. To take out grains, as per need, a special opening is provided near the bottom of each Peru. Interestingly, these structures are invariably kept in a separate room called Overi and access to which is allowed only to very few persons.

The use of bamboo containers allows the free exchange of gases inside the grain and keeping containers on the ground floor ensures cool temperature for storage. Loading from top and unloading from bottom offers easy material handling. Keeping storage structure away form main living room protects grain from fire etc.

In some parts grain is stored in wooden structures known as Darauntha and are kept away from the main living rooms. Daraunthas made of deodar wood are preferred as this wood checks the entry of insects/ larvae.

Wooden houses built away from living quarters check the entry of rodents etc.
Windows with wire mesh, provide adequate ventilation. The size of the store house is proportional to the size of land holdings (Fig 50 a, b & c).

Grain storage in earthen rooms: In some upper parts special earthen rooms are constructed for storing cereal crops immediately after harvest. Storage in such rooms also provides a cool temperature so essential for the storage of grain.

The logic behind constructing these storage houses/rooms at some distance from the family units was to save the food grains from the hazards such as fire, which was a common feature in the early days, as the entire structure of living rooms was fabricated from wood.

**Use of Neem/turmeric/mustard oil in storage**

The use of Neem as a pesticide is now well documented. Similarly Walnut, Bhera and Mint leaves also seem to possess certain antimicrobial or pesticidal properties, which help in grain storage. The antimicrobial substance in mustard is allyl isothiocyanate. The turmeric powder also appears to perform a similar function. Some of the uses to which these natural products put are enlisted below:

Grain is mixed with leaves of Neem/Walnut/Bhera/Mint (Paudina) and then stored in bins.

For storing pulses, especially Urad, the grains are mixed with turmeric powder or smeared lightly with mustard oil and then sealed in air tight containers.

Storage of pulses after soaking in cow urine followed by drying is also practiced in some parts.

However, the scientific basis for storing pulses after soaking them in cow urine is yet to be explained.

**Storage of tuber crops**

In the tribal belt as well as in some other parts of Himachal, at the on-set of winter, root crops like potato, ginger, turmeric, colocasia (arbi) etc are stored in underground pits and the top is covered with thatch and soil. These products are consumed up to the next summer.
Fig 49. "Peri" or "Peru" for grain storage

Fig 50a. Grain storage structure made of wood

Fig 50b. Wooden structure for grain storage

Fig 50c. Inside view
Storage of cabbage heads, meant for seed crop in done, in under ground pits dug in the fields. This is a common practice in Kinnaur. Apart from other storage benefits, the crop is also protected from the hazards of snow.

These methods of storage provide cool conditions for storage of these commodities, ensuring freshness for prolonged use.

Storage of fruit crops

Apple

The apples are stored in the tribal areas of Lahaul-Spiti and Kinnaur districts in the underground pits, prior to the onset of winter. Apples are packed into wooden boxes which are then placed in underground pits and the mouth of pits is covered with thatch and soil. In this way, the apples can be stored up to summer time without any appreciable loss in quality.

The method appears to be a modification of the pit storage procedure described earlier, since here the direct contact of fruit and soil in the pit is prevented. A pitcher or wooden box placed in a pit created a cool store. The development of the zero energy cool chamber (ZECC) appears to have its genesis in this technology.

Drying of Food Crops

Open sun drying of cereals, pulses, oil seed crops and fruit/vegetables is an age old practice used for storage of food grains for long periods throughout Himachal. However, the actual methods of drying, show marginal differences in different regions of the state (Fig 51).

Drying of cereals/pulses/oil seeds

As mentioned earlier, cereals (wheat, paddy), pulses (urad) etc. and oil seeds (sarson etc.) are harvested when they are just ripe and then kept in the open sun in the form of small bundles called Pooi or Pooia for drying. On complete drying, the grain is separated by beating the small bundles against a stone. Due to complete drying, the seeds/grain are easily separated from the husk. However, in present times, threshers and shellers have replaced this practice for wheat and maize respectively. Since completely dry grain is prone to shattering, harvesting crops at the ripe stage, prevents this loss during handling and harvesting.

Drying of Fruit and Vegetable

In the tribal areas and in some parts of Shimla, Sirmour, Kullu and Chamba districts of Himachal Pradesh, fruits such as the apricot, wild apricot (chuli), apple and local grapes (in Kinnaur) etc. are dried under the open sun by spreading them out on the
roof tops. After 10-15 days of continuous drying, the fruit is collected and packed into gunny bags for subsequent use. Except for the uneven slicing of apples with iron sickles (Dratt or Drat) no precaution is administered to any crop. Dried apricot is a commercial product of Kinnaur.

Open sun drying of vegetable like tomatoes, cabbage, turnip (stalk and leaves), mustard leaves is also practised in Kinnaur district and other adjoining areas. After making four incisions on the tomatoes (keeping the slices intact), slicing of turnip (stalks and leaves), cabbage and sarson leaves these are placed in the open sun for drying. After 15-20 days of continuous drying, the dried products are collected and used during the lean season.

In hills of Uttar Pradesh, first put walnut leaves in the bag or vessel in which grains are to be stored. The top is covered with cow dung paste. This saves the grains from stored grain pests (The walnut leaves contain ascorbic acid which is pungent). (Rawat, 1999).

In Karnataka, arhar seeds are dried in sun and then kept in open at night. These are stored in a pot between layers of sand which is closed from top and kept for storage. This saves them from insects (Gorshamma, 1999).

In Jorhat, Assam, use mango leaves with paddy stems to store paddy. No gap is left in plants. The jute bags are soaked in tobacco extract before storing paddy in them to avoid insect attack. (Barua, 1999a).

Ginger is dried in sun after pasting it with cow dung. It is also given neem leaves smoking. This way seed can be stored for a year having moisture in it (Abraham, 1997).

In traditional houses there are underground rooms to store seed. The air circulate in them. The vegetable seeds are smoked and smeared with ash before storing (Abraham, 1997).

Storage of elephant foot in Nigeria

In some villages of Nigeria to avoid rotting of elephant foot crop, people make a temporary roof in the kitchen just above the pot on which the rhizomes are kept. The cooking enhances the humidity in the kitchen which in turn increases the biactivity in rhizomes which keeps them fresh. The smoke also inhibits disease attack on them. This way rhizomes can be stored for 3-4 months.
This practice is also used in Gujrat where farmers keep onion on the temporary roof in the kitchen. This way onion can be stored for more than a year (ChokWoo, 1997).

**Storage of radish**

Radish is an important crop of Bhutanese. It is a major portion of their diet. In off season they have to purchase it at very high price. To store radish the farmers dug 3-4 feet deep pit in the field. The walls and ground of this pit are covered with dry grass and the radish is put in it. The top of the pit is covered with a bamboo mat. This way it can be stored for 4-5 months (Gurang and Richen, 1997).

**Storage of green tomato**

The farmers of Pakil Leguna village in Philippines store tomatoes in baskets making alternate layers of charcoal and tomato fruits in 3-4 layers. The fruits remain fresh for six months. In Bangladesh, farmers hang the whole plants with green tomatoes in inverted position in shade and ventilated place. This helps in preserving them for about 3 months (Lorejo, 1997).

A tribal category of Kanzania burn the dry cowdung, powder it and mix with maize seeds. This stops many pests coming near the stores (Guromcla, 1997).

In Bharatpur, Rajasthan, store wheat grains in straw mixed with neem leaves. The sides of stores are also pasted with mud and cowdung. Neem seed powder is also mixed in grains (Singh and Singh, 1996a).

In Mukteshwar (UP) store wheat grain using neem and walnut leaves (Singh and Singh, 1996 b).

In Udaipur (Rajasthan) farmers sprinkle 50 kg cowdung cake ash per 5-8 qtl. wheat grain (Bherulal, 1996).

In Bharatpur (Rajasthan) keep the tobacco bundle at the entrance of store of grains (Chandrabhan, 1996).

In Kangra (HP) 10 kg salt is mixed in 40 kg wheat and kept in mud store the month of which is sealed with straw and mud (Premnath, 1996).

In Nainital, farmers store seed with asafoetida to avoid pests. A layer of salt 2-5
cm thick around the seed bags is a good control against snails. The dried powder of bittigourd seeds sprinkled on seeds also saves them from insect-pests (Pande, 1999).

In Kanyakumari, farmers mix powder of *Vach* (*Acorus calamus*) in grains before storing paddy, grain and other grains (Thavassinathan, 1999a).

In Karnataka, farmers mix some seeds of *Arand* (*Ricinus communis*) with grains before storage (Bhuthaligappa, 1999).

The Gursia tribes of Udaipur, Rajasthan bury the sugarcane stems in 5-6 ft trenches to save them from termite and ants (Sharma, 1999d).

In Dodoma, Tanzania, farmers spray 20 kg cobdust on maize grains against seed borers (Kitang, 1999).

**Storage of turmeric**

People in Junagarh (Rajasthan) dig a pit of 15x10x6.5 feet at some elevation and cover its sides with datepalm leaves. The space between the leaves is filled with wheat straw. Now the turmeric bags are kept one above another filling the space in between with datepalm leaves and wheat straw. To avoid entry of air, they cover the top with datepalm leaves and paste with cowdung. Upto 15 tonne turmeric can be stored per pit for many months (Sharma, 1997b).

In Bangladesh, farmers mix 1 kg tomato fruits with 2 kg clay soil and make small pellets of it which are bound in the form of a necklace and hung in kitchen to avoid attack to stored grains (Majumdar, 1999).

The farmers let the cucurbits dry on the plant itself. The dried fruit is given a hole at the one end and filled with cowdung. After 10-15 days when the pulp inside gets rotten a stick is inserted in the fruit due to which the dried seeds come out. The seeds are separated dried and stored in airtight containers. The hollow fruits are used for storing material (Bangladesh) (Sattar, 1999).

In Bangladesh, the lobia pods are left on the crippers to dry. The dried pods are bound to form a necklace and hung in the kitchen. The warmth in the kitchen keeps their moisture content 10 per cent which save them from diseases (Majumdar, 1999).

In Chitradurga, a village of Karnataka, farmers use various practices for storage of grapes (Prasad, 1999a).
Mix 50 gm arand oil with 25 g turmeric powder for one kg seed. This seed is then dried in sun and stored. They also store seeds using 100 g chilly powder, 100 gm salt per kg of seed. The gramin is mixed with green red chillies, dried in sun and store. To avoid the attack of borer on bitters bottle gourd and gram. Farmers dry the whole fruits. The grains seeds are washed with cow urine, dried in shade followed by sun drying and stored in earthern pots. Few farmers mix sand and seeds in equal proportion before storage.

In West bengal, farmers spread Bane (Vitex negundo) leaves and branches in the and around the bags used for paddy storage (Naskar, 1999).

The farmers of Nadia, West bengal put salt in the paddy straw layers to save it from rats and other pests (Ali, 1999).

Apricot during on the trees

In the high altitude dry areas e.g. Malling, Nako, Pooh, etc., in Kinnaur district, apricots are not harvested fresh but allowed to dry on the tree itself. Due to very low relative humidity, the apricots dry rather well on the tree. The dried products is of excellent quality, not obtained even after adopting modern techniques of drying (e.g. checking, sulphuring and mechanical dehydration). The apricots dried on the trees are approximately two to three times more expensive than sun dried apricots.

The prevalence of low temperature and dry weather conditions help first in the accumulation of sugar in the fruits and then in the subsequent drying of the fruit to develop a rich colour and sweetness in the product. This is one example of low temperature drying under natural conditions.

Drying and preservation of meat

In some parts of Shimla, Kinnaur, Lahaul and Spiti and Chamba districts, meat is dried for use during winters, by hanging strips of meat on stings tied across the room. Due to heavy snow, and the low temperature spoilage of the products is prevented. At low temperature and very low humidity, the meat dries very well and is hence preserved better for longer period.

In some places, salt is also sprinkled on the carcass prior to drying, which also assists in preservation.

In Nako and Malling areas of Kinnaur district, the meat is hung in the kitchen. The smoke from the hearth (Chullah) serves to smoke the meat, and hence preserves it.
In some parts meat is preserved by smearing it with a mixture of mustard oil and turmeric powder.

Low temperature checks the growth of micro-organisms. Reduction in water activity by drying and use of salt helps in preservation. Smoking is one of the oldest methods of food preservation. Both mustard oil and turmeric powder are known to possess antimicrobial properties, and thus help in preserving meat.

**Distilled Country Liquor**

Preparation of alcoholic beverages by distillation is common throughout the tribal belt of Himachal Pradesh. Government excise department too permits this practice, allowing each family to keep upto 24 bottles in its possession at any given time thereby acknowledging the socio-culture fabric of the region.

**Fermentation**

The liquid is prepared from fruits like local grapes (coloured and seeded), apricot, wild apricot (*chuli*), pear, apple, wild almond (*bemi*), etc. In higher reaches of Kinnaur, however, millet is the main ingredient. Country liquor is a strong alcoholic drink obtained after distillation of fermented musk.

Fruits like apple or pear are cut into coarse pieces, grapes, chuli and apricots are either hand washed or washed by feet and then placed into large tanks (concrete or wooden). In the agricultural lean period, dried fruits like apple slices, grapes and chuli are also used for this purpose. Generally wooden drums are preferred for fermentation as they maintain suitable temperatures. To obtain higher alcohol output, occasionally molasses are also added to the fermenting musk. Drums are then tightly sealed with wooden or heavy stone lids (Weather permitting, the fermentation continues for 15-20 days). The completion of fermentation is judged using different parameters like alcoholic or acetuous odour, small vapours appearing on the inside of the lid or non-sticky nature of the pulp, when pressed between the forefinger and the thumb. All these characteristics are indicative of complete fermentation.

In some places the fermenting vat or bottle is placed in a cow dung pit (*Mahtash*). Generation of heat during decomposition of cow dung in the pit provides required warmth for faster and better fermentation.

**Distillation**

The fermented musk is then distilled to obtain the liquor by different methods.
Fig 51. Sun drying of cereal crops

Fig 52. Distillation of fermented musk for preparing country liquor (Ghani)

Fig 53. 'Ghani' liquor distillation system provided with rubber pipe

Fig 54. Traditional method of country liquor distillation
The fermented liquid is boiled in a vessel called as Balti. At the base of which a temporary stand is made under place a container to collect distilled liquor. Upon heating, the fermented liquid boils, and its vapours are cooled by striking the top of the container (holding cold water), the condensed vapours drop into the container, meant for collecting the liquor (Fig 52). Cold water is repeatedly replaced until the process is completed.

In this manner, recovery is comparatively low since some vapours also fall back into the boiling liquid. Moreover, there is no provision for complete separation of its methyal alcohol content.

In some places, this method has been further improved as under:

Herein, an empty ghee tin (canister 15 kg capacity) is made slightly rounded, and at its base, is placed a temporary stand on which a pot is placed for collecting the condensed vapours. The pot is attached to a rubber pipe to receive the liquor in bottles/plastic cans (Fig 53). This has a higher efficiency and it also allows the separation of the initial drops of the liquor which contain high levels of methanol.

As a further improvement in the distillation process, the fermented musk is placed in a metallic pitcher which is covered with a (stone) slate with a hole at its centre for the passing out vapours. The slate is used ostensibly to avoid the overflow of the material as it boils. Another metallic pan with a hole is kept on the slate and is attached to a side pipe where condensed alcoholic vapours are collected. To cool the vapours, this container is housed in a bigger metal pan which is cooled by continuously running tap water. Two rubber pipes viz. inlet and outlet aid the circulation of cold water and the release of warm water. The pan is maintained in a tilted position, so that the inlet of the pipe is located higher than the outlet pipe. The bottom of the utensil is cooled, thus the alcoholic vapours condense on its lower surface. The condensed material runs out through the side pipe of the lower utensil from where it is collected into bottles or plastic cans (Fig 53). Approximately, 12-14 bottles of alcohol are collected from 40 kg of fermented musk. However, by using 5-6 kg of molasses/gur in this musk, the yield increases to 18-19 bottles. Fuel wood is used for heating. All joints are secured using barley, phafra or wheat paste. In some places even dung paste is used for securing joints.

The simplest method involves a rubber pipe being inserted through a hole in the slate lid, to collect the vapours. The vapours are cooled by maintaining a continuous flow of cold water from the tap. The condensed alcoholic vapours are received in the bottles (Fig 54).
Improved method of distilling country liquor

In some areas of Himachal the above stated methods have been further improved by replacing the water through by rubber pipe, to collect vapours from the boiling fermented liquor. In this method an empty ghee tin i.e. 15kg capacity canister, is used for boiling the fermented liquid by heating it on fire. On the top opening of the canister, a rubber pipe is inserted to receive the alcoholic vapours, the pipe is paired through a water trough to condense the vapours. The alcoholic product is then collected in glass bottles or plastic cans.

In order to increase the alcohol yield Gur is sometimes added. In the agricultural lean period, dried grapes, apple and chuhl etc. are used for preparing the fermented musk (Fig 55).

The product prepared from grapes is called Angoori. Chhang is prepared using Millets and Ghanti prepared from any other source. During initial distillation, first 1-2 bottles of liquor are called Moori and contain the maximum amount of alcohol while last distillate contains comparatively lower amounts of alcohol and is called Rash. Costwise, Angoori is the costliest, followed by Moori and least expensive is Rash often only Rs. 10-20 per bottle (700 ml).

Due to extreme winters, the consumption of country liquor (ghanti) is extensive in the entire cold desert regions for medicinal purposes. Besides social use the product is also used during rituals and religious occasions.

Traditional Apple Plucking

It is done by climbing an apple tree with putting by a small basket made, which is put around the neck of gunny bag cloth. This prevents the damage of fruits. Plucked apples, from the gunny bags are transferred to a bigger basket (Kitta) which is also provided with a rough cloth cushion. In this way, apples are carried to the store room for grading (Fig 56).

WEATHER FORECASTING

Weather is certainly the most important factor determining the success or the failure of agricultural enterprises. It manifests itself through its effects on soil, plant growth as well as on every phase of animal growth and development. A greater proportion of the total annual crop loss results from aberrant weather. Also crop and animal disease are greatly influenced by weather. In all, weather accounts for approximately three fourth
Fig 55. Traditional continuous distillation method of country liquor

Fig 56. Traditional apple plucking
of the annual loss in farm production both directly and indirectly.

However, the crop losses can be reduced substantially by affecting adjustment through timely and accurate weather forecasts. Such weather forecast support also provides guidelines for long range or seasonal planning and selection of crops best suited to the anticipated climatic conditions.

Weather forecasts for agriculture can be grouped into short range forecast (upto 48 hours), medium range forecast (3-10 days) and long range forecast (one week to entire season). Each plays an important role in farm operations and planning of agricultural activities. Most important efforts since time immemorial have been on rain making and weather forecasting. Some of the indigenous practices are recorded here.

**History of Indigenous Rain Making**

From the food gathering stage to the last quarter of the twentieth century, man's need for water has been increasing. However, the unpredictable nature of rainfall has not changed. Adequate availability of water through rainfall has, therefore, always been the major worry of man, leaving him susceptible to any activity that could bring rain. Just as present day heads of government are concerned and incorporate plans for the adequate supply of water for their people, similarly primitive tribal chiefs were also responsible for bringing rain to their people. Like the politicians of today, the tribal chiefs, delegated the responsibility of rain making to someone else, obviously as a hedge against failure. If there was no rain, it was the luckless assistant who was punished rather than the chief.

The early rain makers, forerunners of the present day meteorologists, were perhaps among the most intelligent of the primitive men who had to guess the scientific reason for the phenomenon of rain and the fact that these gentlemen often succeeded in duping their chiefs to preserve their own lives is in itself a tribute to their intelligence. Again, it was these very people who set the stage for scientific enquiry into the causes of weather and rainfall.

**Magic and rain making**

During the intermediate stage i.e. between magic and science, religion and pseudoscience gained importance in rain making. Initial attempts for making rain started with magic. At different times, in different countries, rain makers have performed strange ceremonies like invoking the spirits of the dead, mock ploughing, even hurling curses at the Gods.
The pioneer rain makers were magicians who used imitation, appeal, supplication and even intimidation as approaches to make rain. They sprinkled water on soil, hoping the heavens would do the same. They beat drums, used to imitating thunder, used firebrands to simulate lightening and blew mouthfuls of water into the air like rain. Women poured water on soil, hoping the heavens would do the same. Water was blown into the air through special pipes, and blood was sprinkled on the soil to bring rain. Bathing in rivers, even ploughing rivers was resorted to in attempts to bring rain. Frogs were hung from trees to induce the heavens to make it rain over them.

When imitation failed, magicians often turned to supplication. Children were buried neck deep in the soil to cry for rain, shedding tears to imitate rain. Where supplication too failed, intimidation was resorted to. Magicians would run in various directions flailing at the sky with a stick or sword, commanding for it to rain. Even today, in many parts of the world rain making is practised though there are many variations to this weather magic.

Religion in rain making

It is difficult to mention the exact time when the rain makers turned from magic to the Gods. Imitative magic gave way to supplication, a sympathy inducing approach directed, not towards clouds and the heavens, but towards Gods representing these phenomena. During the earlier stages, tribal chiefs or appointed rain makers were regarded as the source of rain. This respect subsequently shifted to the dead. Thus supplications were first directed at the tomb of a departed ancestor. Men prayed for rain to the dead and then to the Gods. Praying for rain is firmly rooted in Indian culture even today.

It was believed that prayer itself could bring rain. But as an insurance, non living gifts were presented to the rain God during the prayers.

In the temperate Himalayas, people sing the traditional song, singaitoo up to mid night during the prolonged hot dry summer. They then organise a feast (Havan) from the collections made, in honour of Khawaja God. People calim that in this way the rain Gods are appeased and within 2-3 days of the feast rainfall is assured. A similar type of feast (Varisty Puja) is organised by villagers collectively during summers in the event of a long dry spell in Punjab. All cry for rain and the children sing a song, The essence of the song is:

"When God listens to children’s voices there is rainfall"

In the next stage of its evolution rain making was centered around the bestowing
of gifts through sacrificial offerings. Initially these were in the form of live human sacrifices, and subsequently involved animals. Intimidation was also an important tool in religious practice. In China, huge paper dragons were part of religious festivals and when the rains failed, these dragons were angrily torn apart. In several European countries statues of saints were uprooted and made to stand on their heads when prayers before them failed to bring rain. As late as 1893, Italians, affected by long periods of drought, banished statues of saints from their country. On occasion the statues were chained and their wings were clipped off, one prevalent in Europe was to erect bells and crosses to protect the vineyards. The bells were thought to prevent hails, lightening and windstorm. When the Gods failed to bring rain through prayer or intimidation neighbours were approached. In Bengal when the end of the drought was not in sight, people threw filth on the homes of their neighbours who in turn abused them; this was considered auspicious for rainfall.

In the Shahpur district of Pakistan, people would throw a pot of filth on the threshold of a notorious shrew of the area during a drought. This, not surprisingly, resulted in a fluent stream of foul language which accelerated the onset of rain.

**Pseudo-science and rain making**

When magic and religion become a natural truth then it can be considered a pseudo-science or sometimes even science may be applicable to the natural truth. One of the observations of a natural truth was the occurrence of rainfall after the great battle was over.

The religious explanation behind this coincidence was that the Gods were offended by the carnage and had sent the rain to purge the land of blood. The materialistic answer for this coincidence was different. Rain was simply the condensation of the blood, sweat and tears of the warriors. There were other theories also. One was that noise might have caused the rain: the great inferno of blazing guns and screams produced the rain. All these theories, however, were later on demolished. Battles are fought generally in good weather in wet regions and when the battles are over, it was generally the time for the onset of rain. People observed that rain induces lightening and thunder rather than vice versa. An American argument in favour of smoke noise theory was the rainfall in the 4th of July and it was argued that fireworks did it. In fact this was, and is, the peak of the rainy season in the USA.

In 1880, a patent was issued in the USA for using balloons loaded with explosive for rain making because the explosion theory/belief held sway for a considerable time.
Powdered lime was used to stop rain in certain areas and other chemicals were used to induce rain. In 1899, meteorologist Aitken discovered the phenomenon of condensation. So then these nuclei were added to induce rain.

The nuclei used was dust, if this did not work sulphuric acid was used which produced bubbles that flew into the air. The explanation put forth for this experimentation was that chemical action produced hydrogen which being lighter rose high in the atmosphere and in doing so created currents that carried moisture for condensation. In later years, however, the actual facts discredited this explanation or claim. To date there is no successful method of rain making, hence means of adjustment to the cycle of rain were and are indeed important.

**ITK for Weather Prediction**

Out of various the factors which control agricultural production, weather is the only factor over which man has no control and hence it has an overwhelming dominance over the success or failure of agricultural enterprise. It is an accepted fact that food production is inextricably linked with climate and weather. It is also reported that weather induced variability of food production is more than 10 per cent. This variability can be as high as 50 per cent of the normal production in respect of smaller areas situated in arid and semi-arid regions. In order to reduce risks of loss in food production due to the vagaries of weather, weather per se, should be taken into account as one of the major inputs in agricultural planning. That is why forecast of weather parameters play a vital role in agricultural production. It also aids in minimise crop losses to a considerable extent. Thus development and refinement of the art of weather prediction has been essential since time immemorial.

In present times we have many improved technologies for making weather forecasts as well as for their dissemination. Previously available farmers based their prediction on many natural, cultural and social phenomena. Some of these are discussed below:

**Visible spectrum around the sun and the moon**

People predicted weather after observing the visible spectrum around the sun or moon. If the spectrum around the sun had a greater diameter than that around the moon, they predicted rainfall after a day or two.

Some people based their weather prediction on the nature of the solar halo, specifically: "If the spectrum around the sun has a larger diameter then rainfall is assured".
All the photometers are a luminous phenomenon produced by the reflection, refraction, diffraction or interference of light from the sun or moon. The visible spectrum of light around the sun or moon is called halo, or corona according to its distance from the sun or moon. If the distance is more then it is called the halo phenomenon, which is caused by a layer of thin veil of cirrus clouds i.e. non rain bearing clouds. But if the distance is less, it is called corona phenomena produced by somewhat dense clouds which may cause rainfall. The accuracy of this indigenous observation can be as high as 50 per cent.

Cloud and wind direction

If there is an accumulation of clouds in the South-East direction in layered form accompanied by winds blowing from the southern direction then it is claimed that there will be rainfall within a day or two.

Weather prediction through birds and other animals

Farmers also predict weather by observing closely the different activities of various birds, animals etc. The following are some indigenous beliefs:

- It is believed that on a hot summer day the cry of the bird called "Nialu" for water brings rainfall.
- During the rainy season farmers observe the "Matilari" bird (House swift) and they predict heavy rainfall if the bird flies high in the sky.
- If the Mayna bird bathes in the water it indicates that there will be rainfall within one or two days.
- During long hot days in summer if the cry of "theapiha" bird is heard then people believe that God will quench her thirst and ther will be rainfall after one or two days.
- A group of sparrows frolicking in the sand indicates that there will be rainfall that day or the next day and if they are observed to be playing in water then it is believed that the weather will be dry for some days to come.
- If the 'Jonks' (Lecchs) are immobile/ stationary at the water surface (Pond) then dry weather is predicted but if they move rapidly in the upward and downward direction in water then rainfall is predicted.
- If the "Tatihar"bird (Lapwing) lays her eggs on the higher portion of the field then heavy rainfall is predicted during the coming rainy season but if the eggs are laid in the lower portion of the field then a drought is predicted. These birds never construct a nest but lay their eggs on bare soil.
Further it is also believed that if a single egg is laid, then there will be rainfall only one month out of four months of the rainy season. If two eggs are laid then rainfall will occur for two months and similarly four eggs indicate there will be rainfall during all the four months of the rainy season.

- If the "Trillbohara" (Dragon fly), which appears generally in the rainy season, are observed to swarm in a large group over a water surface (Pond) then dry weather is predicted but if they swarm over open dry lands or fields the early rainfall is predicted by the farmers.

- If the colour of the clouds is similar to the colour of the wings of the Titar bird (Partridge) i.e. grey or black-grey and strong eastern winds are also blowing then assured rainfall is predicted by the farmers. The clouds of a colour similar to that of the said bird are rain bearing clouds i.e. of cumulonimbus type.

- If centipedes emerge from their holes carrying their eggs in swarms in order to shift them to safer places (within the house) then farmers predict early rainfall. The centipedes do this so as to avoid egg damage which can be caused by rain water.

- When spider nets are plentiful on grasses, sticks of tomato crop and on french bean crop then it is estimated that the rainy season is over.

Social and Culture Beliefs

- Many cultural, social and religious beliefs and activities superstitions pertaining to the prediction of future weather prevail since generations. From time immemorial farmers have predicted the weather on the basis of these beliefs/activities. The following are some examples from the western Himalayan region.

- If the first 10-15 of the month "Jeth" (May-June) are very hot then good rainfall / monsoon is predicted during the ensuring rainy season. This results probably from the low pressure zone in north-west India that is generated due to the high temperatures.

- It is also believed, that when grey coloured clouds descend below the hill tops then they definitely cause rainfall.

- If the "Khajiri" tree bears good fruit in a particular year then farmers predict good rainfall during the next rainy season and vice versa less rain is predicted in the event of a poor fruit crop.

- If the Chakkala-Belan, (rolling pin and board), used in the Kitchen, show moisture on them then within few days rainfall is expected.

- In villages elderly farmers usually carry a small bag for "Tambaku" (Tobacco) for Hukka (Smoking device). When this bag shows more moisture in the Tambaku then farmers predict rainfall within one or two days.
Some Folk-lore Regarding Weather Forecasting

The folk-lore of the popular poet Gag and his wife Bhuhdari, who lived during the 17th century, regarding weather forecasting are still very popular in northern India. Some are given as under:-

"When strong eastern winds blow continuously then it is estimated that the rainy season has come".

- When days are very hot and there is dew at night, then according to Gag, there are very limited chances of rainfall.
- When cloudy days are accompanied by clear nights and the eastern winds blow somewhat strongly, then according to Gag no rainfall is predicted. Thus there is accompanied by a shortage of water in ponds, rivers etc. Consequently clothes are washed using water from wells.
- When a rainbow is formed in the direction of Bengal then there will be rainfall, if not by the evening then definitely by next morning.
- During the rainy season, if a cloud appears on Friday and Saturday then rainfall is predicted either for Sunday or Monday.

People use different techniques to forecast weather

In Baisakha put four mud pieces in the field and put an earthen pot filled with water over them. If all four pieces get soaked it shows that the rain will occur for all the four months in monsoon; if three pieces are soaked then for three months only and so on (Agra, UP) (Lal, 1996).

If swelling is observed on the lower leg portion of camels, it indicates rain (Agra, UP) (Singh, 1996).

Dragon fly if seen near water sources indicates early rain (Bharatpur, Rajasthan) (Vyas, 199b).

If the tobacco bag gets moisture it indicates early rain (Bharatpur, Rajasthan) (Devendra, 1996).

If a sparrow baths in water, it shows no rain but if it bathes in dust it shows rain (Pachori et al., 1996).

In Srilanka, the farmers use the nests of crows as indication of monsoon. If there is only one egg in the nest the rain will be very less during that year. More the eggs more in the rain. If the honeybees make their hives in the unprotected places it shows that there will be no rain (Gunaskera, 1999).
Kanani et al. (1997) of Junagarh Agriculture College in Gujarat in 1990 recorded the clouds and rain position everyday. They also recorded the direction of wind, formation of clouds, level of humidity, lightening and time of sun rise and sun set. They compared it with the knowledge of people about climate and found that:

If the clouds sound, lightening occurs and heavy rains in experienced on the second day of start of the Jetha month then the rain discontinues for 72 days.

If the rain occurs in Magh Nakshtra then rain occurs in rest of the Nakshtras like Purva, Utra, Hasta, Chitra and Swati also.

If the eleventh day of Asadha falls on Sunday, Saturday or Tuesday then rain occurs where less rain appears.

If rain occurs in last ten days of Mrig Sheersh then no rain is experienced in rest of the ten Nakshtras.

If rain occurs in Adra Nakshtra then less rain is experienced in rest of the Nakshtras.

If rain occurs on second and fifth day in the first fortnight of Aashadha, then rain is experienced in the first fortnight of Shravana.

Some of the beliefs about rain are (Kanani et al., 1997):

If the sky turns red, it indicates heavy rainfall. Inversely, the yellowish colour on sky the probability of rain decreases.

The heavy wind blow from east accompanied by mango fruits falling from trees and lightening in the north indicates heavy rainfall.

The southern winds in Posh (winter) month indicate heavy rainfall in rainy season.

Brown clouds indicate rain, whereas, black clouds are just for showoff.

If rain occurs in Chaitra then monsoon goes dry in that year.

For weather forecasting the tribals of Udaipur, Rajasthan have their traditional ways (Sharma, 1999).
The heavy fruiting on Dhak (Buta monosperma) indicates heavy crop of paddy that year.

Farmers start sowing the Kharif crops as soon as new flushes appear on wild banana which indicates early monsoon.

Sahni et al., 1997 has compiled the ITK on the plants and birds as indicates of rain as follows:

If the crows name their nests on highest branches then heavy rain fall shall be experienced in monsoon and rain will occur soon. The making of nests by them on the lower branches is bad news regarding rain.

In case the snakes are seen resting on high branches in the forests and stay there for some time, it show that the site shall experience rain soon. If no one see snakes on higher branches, then in that year the season will go dry.

The villagers of Sawai Madhopur (Rajasthan) use the locations of tortoise burrows as indicative of intensity of monsoon. The inhabitants of the village located near the Banas river inspect the burrows of sweet water tortoise. They estimate the intensity of rain depending upon the location of burrows on the terraces.

If the cow cries at night and fox barks in the day time, it shows long dry spell.

The farmers in baroda assume that if the water drops from aerial roots of banyan tree, it indicates early raining. The quantity of drops shows the intensity of rainfall.

Heavy rain and prolonged monsoon occur during the years the cactus plants bear flowers.

The size of fruits on tamarind plants show the intensity of rain, bigger the fruits heavier the rain in those years.

**TOOLS AND IMPLEMENTS**

In the upper Himalayas, varied topographic and agro-climatic conditions ranging from subtropical to cool temperatures permit the cultivation of a wide variety of crops and fruits. However, agriculture in general is handicapped due to steep and hilly terrain, hazards of climate, uneconomic scattered holdings comprising of shallow and stony
soils. The tools and implements used are of a primitive nature throughout the Indian Himalayan range(s). Traditional farm tools and implements for self sustenance have been developed/modified through experience over generations to meet emerging socio-economic and farming challenges. The type of soils and topographic conditions largely influence the type, size and shape of particular tillage tools/implements. The following is a list of local tools/implements found in various regions of temperate Himalayans.

A brief discussion of the most commonly used indigenous implements are given in table.

**Tillage Implements**

1. **Plough**: Tillage is the basic operation in farming. It is done to create favourable conditions for seed placement and plant growth. This is done mainly with a plough. A full history of the evolution of plough is not available. Farmers have been using plough since time immemorial. The primitive model might have been a crooked twig or a branch of a tree. The basic components of the plough are a shoe, a share, a body, a handle and a beam.

The shoe and body make one piece in the case of ploughs being used in Kullu, Solan, Shimla, Sirmour, Lahaul & Spiti and Kinnaur district of Himachal Pradesh. The joint between the shoe and the body is purposely avoided with a view to make the plough more rigid and robust, so that the implement can work on gravelly soils with stones and other obstacles which are encountered during the course of ploughing. (Fig 57a,b & c)

The shoe, used in the plough, can be of different shapes and sizes. Ploughs used in dry lands have shoes which are generally of a triangular section while in wet land cultivation the shoes are of a more flat section.

The share is prepared from a mild steel bar, 0.6 to .75 m in length and 1.5 to 2.5 cm in width. The share is fixed to the shoe or body by means of a U-clamp or ring shaped clamp. The share point projects beyond the shoe by 5 to 7.5 cm. Beams generally vary in length form 2.4 to 3 m.

2. **Yoke**: The yoke has a projection at the centre to which a beam of implements like plough, leveller and harrow etc. are secured by a rope (Fig 58).

3. **Leveller**: The plank of the leveller is made of any locally available wood and shafts are generally made of bamboo sticks. Extra weight is added to all type of planks by
Fig 57a. Traditional plough

Fig 57b. Traditional plough

Fig 57c. Traditional plough

Fig 58. Neck yoke (junga)

Fig 59a. Leveller (Suhaga)

Fig 59b. Leveller (Suhaga)

Fig 60. Harrow (Dandal)
placing stones on it or having person (s) ride on it. As the name suggests, levellers are used for levelling land (Fig 59 a & b).

4. Harrow: It has a wooden plank to which wood/iron pegs, handle and bamboo shaft are fitted. It is used for breaking soil crust after rain and also for uprooting weeds (Fig 60).

5. Mallot: It has a wooden block to which a handle is attached. Occasionally, one end of the block is tapering. It is used for the breaking of clods (Fig 61).

Interculture Operation Tools

1. Khilna: Its handle is made of a branch of sturdy wood and the tool itself is made of iron and is shaped like an arrowhead. It is used for uprooting of weeds (Fig 62).

2. Kudali: Used for digging and weeding operations (Fig 63), it is made of materials similar to Khilna with the exception that the iron end is flat.

Harvesting Tools

The most common type of harvesting implement are small sickle, big sickle, darat, gandasa and small axe etc., (Fig 64 a, b, c & d).

The hand sickle is used to harvest crops like wheat, maize, barley, pulses and grass etc. Big sickle (Darat) is used to harvest fodder from trees. Gandasa (chopper) and axe are used to harvest crops like sugar-cane etc.

Postharvest Tools and Implements

1. Wooden Pin: It is used to remove the outer covering of maize cobs and is fashioned out of a bamboo stick.

2. Wooden Pole: These are used to detach grains from the maize cobs and grains from other crops through a beating action.

3. Suhaga: This is used to thresh both wheat and paddy crops according to traditional practice through the rubbing action of the suhaga with the tillers of crops.

4. Bamboo basket (Kilta): This is used for carrying FYM and farm produce (Fig 65).
5. Tokri: (Fig 66) A small bamboo basket.

6. Hand mill: This is used to grind flour and pulses (Fig 67).

7. Winnowing: This separates the grain from the husk (Fig 68).

8. Sieve: This is used for the separation of different types of grains for elimination of alien material (Fig 69).

9. Sack: It is used to store the farm produce. The traditional sack is made from the skin of sheep and goat (Fig 70).

10. Shearer: This is used for shearing wool (Fig 71).

11. Skinner: This is used for taking off the skin of slaughtered goat/sheep (Fig 72).

12. Pine needle collecting tool (Fig 73).

Miscellaneous Tools

Hammer, jumper, wedge and shovel and hand saw are also used from time to time in the various farm operations.

Despite of their widespread use, even today, these indigenous implement/tools in general are not agronomically sound and as a result lower the efficiency and increase tiredness of the operator. There is an urgent need to improve upon the traditional implements so as to redress this serious limitation. The standardization of their design in accordance with the requirements of hill farming is long overdue.
Fig 67. Indigenous hand-mill

Fig 68. Winnowing (Shoop)

Fig 69. Sieve (Chanani)

Fig 70. Sack made of goat skin

Fig 71. Shear (Balwan)

Fig 72. Sheep/goat skinner (Katru)

Fig 73. Toll for collecting pine needles (Kadera)
### List of tools/implements used in Kinnaur

<table>
<thead>
<tr>
<th>Type of tools/ implements</th>
<th>English name</th>
<th>Local name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Tillage and bed/land preparation tools</td>
<td>1. Wooden plough</td>
<td>Thoug (Aawi)</td>
</tr>
<tr>
<td></td>
<td>2. Hammer wooden (Mallot)</td>
<td>Ghoon</td>
</tr>
<tr>
<td></td>
<td>3. Leveller</td>
<td>Jorah</td>
</tr>
<tr>
<td></td>
<td>4. Pick axe</td>
<td>Bileha</td>
</tr>
<tr>
<td>2. Interculture operation tools</td>
<td>1. Harrow</td>
<td>Gyama</td>
</tr>
<tr>
<td></td>
<td>2. Khilna</td>
<td>Chikri</td>
</tr>
<tr>
<td></td>
<td>3. Hoe (Kudal)</td>
<td>Khassi</td>
</tr>
<tr>
<td></td>
<td>4. Hand hoe</td>
<td>Khot</td>
</tr>
<tr>
<td>3. Harvesting</td>
<td>1. Scythe</td>
<td>Sora (Daachi)</td>
</tr>
<tr>
<td></td>
<td>2. Big sickle</td>
<td>Naryal (Daach)</td>
</tr>
<tr>
<td></td>
<td>3. Plough</td>
<td>Jhong</td>
</tr>
<tr>
<td>4. Postharvest bamboo pin</td>
<td>1. Threshing pole</td>
<td>Berka</td>
</tr>
<tr>
<td></td>
<td>2. Basket</td>
<td>Kilt (Changer)</td>
</tr>
<tr>
<td></td>
<td>3. Suhaga (Leveller)</td>
<td>Jorah</td>
</tr>
<tr>
<td></td>
<td>4. Large sieve</td>
<td>Yara</td>
</tr>
<tr>
<td></td>
<td>5. Threshing floor</td>
<td>Kholang</td>
</tr>
<tr>
<td></td>
<td>6. Sack (Bag)</td>
<td>Phat</td>
</tr>
<tr>
<td>5. Additional</td>
<td>1. Jumper</td>
<td>Zabbal</td>
</tr>
</tbody>
</table>