Traditional methods of water management in the central Himalayan agriculture

G C S Negi* and K D Kandpal
G. B. Pant Institute of Himalayan Environment & Development,
Kosi-Katarmal, Almora 263 645 (Uttaranchal), India
E-mail: gesnegi@yahoo.co.in

Received 23 September 2002; revised 9 December 2002

In the central Himalayan mountains a rich heritage of traditional methods for water conservation exists. A whole range of indigenous methods is in practice to store and use water for irrigation and other household purposes. These methods are cost-effective and involve the use of locally available material and human skill to construct the water harvesting structures. People follow some traditional norms with regard to the quantity of irrigation water and schedule / frequency of irrigation for the crops they grow. In all the above practices there is strong community participation for the construction, repair and maintenance of water harvesting structures and rules for sharing the water. Maintenance of crop field bunds, ploughing methods, relay cropping, mulching, putting weeds and crop remains to fire etc. are some of the methods of in-situ moisture conservation and soil fertility improvement practiced by the farmers. Use of household wastewater and rooftop water harvesting to supplement moisture for kitchen garden and household demands, and disposal of excess water from the crop fields is also in practice traditionally.

However, these practices are now degenerating slowly as a consequence of reduction in water resources and apathy of the people for participatory programmes. There is a need to analyze these practices from scientific and socio-economic standpoint to popularize them for cost-effective and environment-friendly management of water resources.

Keywords: Traditional water conservation methods, Irrigation ponds, Rooftop water harvesting, Rainfall-runoff water harvesting, In-situ soil moisture conservation.

The Central Himalayan mountains in India, varying in elevation from 300 to over 7000 m asl, encompass an area of about 51,000 km², from 29° 30’ to 31°30’ N lat., and from 77° to 81° E long. Human settlement in this region has concentrated between 1000 and 2000 m asl, and agri-sylvi-pastoral mode is the predominant way of livelihood. About 15% geographical area of the region is under agriculture and only 10% of it is irrigated. On an average, only 0.8 ha land is available per household of 5-6 family members, which may be distributed in as many as 30 tiny terraces varying in size from 0.01 to 0.058 ha. This situation
limits the use of productive inputs and it has been found that the present form and size of agriculture is insufficient to support the food grain demand of the local people\(^2\). These constraints have triggered abandonment of marginal crop fields in this region\(^4\). This region receives about two-thirds of the annual rainfall (150-250 cm) during monsoon season (mid-June to mid-September), and regarded as the storehouse of snow and ice reservoirs making headwaters of many important rivers of northern India. In the recent decades a reduction in rainfall and discharge from these water sources has been witnessed. Many perennial water sources have become seasonal and some of them have dried up\(^6\). People have also noticed a decline in soil fertility and crop yields. In some places the once irrigated fields producing plenty of food grain have either been abandoned or support growth of coarse grains (drought resistant crops). Once strong community management practices for the use of water resources for irrigation are hardly in practice now. In the face of scarcity of water resources many adaptive strategies are coming up. Social institutions, such as water councils (pani panchayats) are also being formed.

This study was carried out to document the various indigenous water conservation (IWC) methods practiced by the farming communities in the rural areas of the central Himalayan mountains. Information on IWC methods was obtained from personal queries with a number of community people including elderly persons and ladies. Sometimes group discussions with the rural people were also held to ascertain the reason behind a given IWC method. Many visits in the rural area of the region were paid to collect the information and verification of these practices was done at the farmer's field level.

A. Irrigation Water Management

1. Canal Irrigation

As elsewhere, in this region also irrigation is mostly done through mud-lined canals (locally called as kuhl or gul) carved out of the hill slopes along the gradient of gravity. To draw water in these canals stream water is diverted placing big boulders across the stream width and the water leakage is sealed with mud and grass. Sometimes thorny bushes or branches of trees are put beneath the boulders, which trap sealing material flowing with the water and also provide shear strength to the diversion structure. In case the crop fields are above the stream water level, the streambed is raised (up to 5 m high) by putting big boulders in the foundation and large stone all across the rim of the diversion structure. Sand and other material brought about by the stream gradually gets deposited upstream and the streambed is suitably raised to divert the water flow to the adjoining canal. Use of strong wooden poles by fixing them vertically and horizontally across the stream width to provide shear strength to the diversion structure is also known as a rare practice of water management.

The main irrigation canal is distributed into several sister canals joining each of the fields in its command area. A sister canal passing through one peasant’s field
conveys water to the following fields belonging to another peasant. Maintenance of canal damaged during ploughing and other agricultural operations and choked due to weeds etc. is the responsibility of the respective field owner. This network of canals is maintained generations after generations and protects the irrigation interests of the farming community. It is noteworthy to see that a network of fine canals, although not legalized, yet works wonderfully well only due to the social cohesion and dependence on each other for irrigation.

In the rainfed crop fields, rainfall is the only source to replenish the soil moisture. Here, peasants practice conservation measures such as, reduced tillage (frequency and depth), and cultivation of drought-resistant crops (e.g. barley, millets, oilseeds and pulses etc.) to cope up with the problem of soil moisture. In normal conditions of rainfall and soil moisture rainfed crop fields are tilled twice and irrigated crop fields thrice for seed sowing. Vegetable fields are tilled / harrowed several time a year depending upon the cropping intensity. Some vegetables require limited harrowing and some require frequent harrowing. However, in case of low soil moisture and drought, tilling is done only once in rainfed crop fields, and tilling depth is reduced by half (<10 cm). People mostly grow local drought-resistant varieties of food crops, which they have selected from long periods of trial-and-error for rainfed conditions.

2. Pond irrigation

This is a common method to store water discharge from minor water sources for irrigation. Ponds are constructed on small seasonal/perennial streams involving whole stakeholder community for construction of water ponding structures and mud-lined canals, and their repair and maintenance. Everyone abides by the rules of operation fixed by the community. People bring necessary equipments and a mud-and-stone structure is built across the stream to block the water flow. Such blockades are usually 5-15 m wide and 1-2 m high. Big boulders are placed at the foundation followed by smaller ones and grass and mud on the top. A hole with blocking arrangement is left at the bottom of the pond and kept close for water impounding. When the reservoir is filled the hole left at the bottom is opened and water is discharged forcefully in the canal for irrigation. The next community member now blocks the hole and uses the ponding water for irrigation subsequently. One such pond is sufficient to irrigate 0.1-0.25 ha crop fields and command area of such ponds is generally 1-2 ha. Sometimes several smaller ponds are created along a stream to irrigate < 1 ha area and may be shared by a few community members.

3. Schedule/frequency of irrigation

In the community run canals the community elders fix schedule of irrigation depending upon the crops, season and availability of water. Priority is given to vegetable crops for irrigation. If the water discharge is low, irrigation is done from tail to head of the canal. Each field owner waits for his turn for irrigation. It may come any time during
day or night. When plenty of water is available irrigation depends upon the choice of the farm owner and there is no fixed rotation. In this situation water is diverted for irrigation at many points across the canal. Sometimes, when the flow is very low the main canal is blocked and water is allowed to fill in through the canal length. Once it is filled up, the blockade is removed suddenly to use the force of water to travel the desired canal distance rapidly. Sometime more than one peasant shares the water thus stored at one time.

4. Quantity of irrigation water
Peasants irrigate crops based on traditional knowledge. In paddy, irrigation is done 7-8 times throughout the growing period when normal water supply is available. Irrigation is preferred either early morning or late evening to escape the warming up of irrigation water due to sunshine, which is considered harmful for the crop. Sometimes when plenty of water is available, small stream of water flowing is left for most of the growing period (July-August) in the rice fields and an outlet from the corner of the fields for the overflow water is left. This continuous supply of fresh water is considered even more beneficial for paddy. For wheat, irrigation is given at 20-25 days interval and altogether 5 irrigations are preferred for the wheat crop. Light irrigation during winter is allowed and water flow is guided to spread over the field uniformly to avoid excessive wetting, which makes the soil cold, and retards tillering and growth of wheat. For tuberous crops such as, potato, onion, radish, turmeric, ginger etc. irrigation at 20 days interval during winter and at 7-8 days interval during summer is practiced.

5. Micro-irrigation
Crops, particularly chillies are transplanted in small circular pits during summer when water scarcity is acute. Transplantation of chilli seedlings is done at dawn so that the tender seedlings acclimatize to dry hot soils overnight and withstand the drying sunlight of the following day. Life saving micro-irrigation is given to the seedlings @ about 200 ml per plant in the morning and evening daily for the initial one week. To make sure that each seedling gets equal water a container measuring about 200 ml is used and filled with water every time after watering a seedling manually from a larger water container kept nearby. In addition, leafy twigs of nearby available bushes are inserted around the pit to provide shade to the tender seedlings for initial 2-3 days for adaptation in the hostile conditions. Similar practice is done for cauliflower, eggplant, and a number of climber vegetables (e.g., bottle gourd, bitter gourd, ridge gourd, snake gourd, pumpkin, etc.).

6. Rainfall-runoff harvesting ponds (khals)
In this age-old practice found in some low rainfall areas of this region natural depressions at the hilltops are used to harvest the rainfall-runoff water. A mud and stone embankment towards sloping end of the hill is created for water impounding. Sometimes, channels are
also created to convey water from the uphill catchment area to these ponds. This water store is mainly meant for use by the cattle during grazing and camping, and percolation of water also benefits the water discharge in downstream sources. Most of these khals are now silted up due to lack of maintenance and people’s participation.

B. In-situ IWC methods in crop fields

1. Crop field bunds

As elsewhere raising crop field bunds and leveling crop fields is an age-old practice for IWC in this region. In irrigated fields bunds of different height/width are maintained. Bunds are maintained at every cropping season and particularly at the time of irrigation of crops. Usually they are 20 cm high, where regular flood irrigation is available and soil is fine, so that the risk of water stagnation and collapse of terrace riser is avoided. Fields having gravelly soil has 20-30 cm high bunds to store more water, as chances of water percolation are high. Sometimes a large terrace is divided into two-three smaller ones for ease of leveling and to ensure spread of irrigation water uniformly.

In the rainfed crop field bunds are not intensively maintained and the fields are also not well leveled. A bund (stone/mud) is raised only when rainwater is expected to collect in the field or move the soil from the sloping end. However, in place of bunds strong root system of local grass develops and it anchors the edge of the fields tightly and soil creep/erosion under rain is arrested. This grass is seasonally cut and used as fodder for stall-feeding the cattle.

2. Ploughing methods

The local people follow a number of practices through ploughing to conserve soil moisture, such as the following:

—Soon after winter rains, crop fields are ploughed and compressed leveling is done using a heavy wooden plate. This is done to bury the soil moisture in deeper soil layers to obtain good seed germination.

—Sometimes ploughing is done soon after crop harvest at the end of rainy season. In this way weeds and soil moisture are buried in deeper soil layers. The weed decomposition increases both soil moisture and soil fertility and favours the germination and growth of the following crop.

—During autumn when the fields are under current fallow, some people saturate fields with water to avoid competition for water during the period of high demand for seedbed preparation for rabi crop.

—In some places seed sowing is done in a circular fashion to raise paddy nursery. This method is water conserving as compared to broadcast sowing and line sowing of paddy seeds to raise nursery. Water flow left at the entry point of outer ring spreads across the whole field in a circular way. Seedling excavation for transplantation is also easier in this method.

—Geometry of ploughing—first and second ploughing is done perpendicular to each other to make sure that no soil is left unploughed. Ploughing is always started from the
sloppy end of the crop field to achieve leveling and reduce soil erosion.

3. Mulching

Crop residue of wheat and dry fodder grass refused by the cattle is used as mulch for in-situ moisture conservation and soil fertility improvement. Mulching seedbeds of vegetable crops such as cauliflower, onion, chilli, eggplant, etc. is a common practice during winter to avoid frost killing, moisture evaporation and to provide warmth and protection to the tender vegetable seedlings. Mulch is also applied to tuberous crops such as turmeric, ginger and colocasia when they are sown during summer to protect soil moisture from evaporation and to increase soil fertility through decomposition of mulch material in the following rainy season.

4. Relay cropping

Relay cropping is another traditional way of utilizing moisture and shade under taller plants of some crops to achieve better germination and growth of a subsidiary crop. Sowing lentil about one week prior to harvest of paddy crop and sowing radish in between the rows of mature maize crop are some of the examples of relay cropping.

5. Soil fertility management and in-situ moisture conservation

There are a number of location-specific indigenous methods for soil fertility restoration and in-situ soil moisture conservation found in this region. Some of the methods are summarized in Table 1.

C. Indigenous management practices to dispose-off excess water

Very often some croplands at the base of the hills are marshy due to seepage from the uplands. Crop cultivation in such land becomes difficult due to excess moisture. Therefore, only some varieties of paddy rice, which tolerate water stagnation, are cultivated on such land. Deep digging of such land is done during spring and the soil is allowed to dry. Few more rounds of digging take place at suitable intervals depending upon the soil moisture left. Deep channels (about 1 m) are dug out towards the edge of the terraces, and sometimes in between the larger fields. The sub-surface water seeps into these channels and safely runs away from the cropland. Often more than one peasant owns such land and they all coordinate to make channels for the safe disposal of water away from the marshy land.

D. Roof top water harvesting

In this region rooftops are made up of slates. During rainfall water drips from the rooftop and is collected putting containers beneath on the courtyard. Usually this water is used for cattle (drinking and washing), cleaning clothes, utensils and house premises, toilet cleaning, and rarely for drinking (only when the water is sufficiently clean). Traditionally, there is no special structure on the roof to guide the overflowing rainwater at a fixed location. Therefore, most of the water just flows down through the courtyard and finds its way through holes kept for the outlet of this
Table 1—Some indigenous methods of soil fertility management and in-situ moisture conservation in the Central Himalayan mountains

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages (SWC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Collection of pine leaves from the nearby forests, spreading them over the crop fields and putting them to fire at the time of sowing paddy rice (summer).</td>
<td>The inflammable pine needles burn rapidly and consume the weeds and their seed/root stock at the soil surface. The ash is considered to increase soil fertility. Reduced severity of forest fire due to the use of pine needles is another advantage of this practice.</td>
</tr>
<tr>
<td>2. Weeds and minor crop remains are gathered, allowed to dry and put to fire on the crop fields.</td>
<td>Ash is believed to enhance soil fertility and weed infestation is controlled due to burning of rootstock and seeds.</td>
</tr>
<tr>
<td>3. Vegetal remains/refuse of stall-fed fodder to the livestock is transported to the nearby crop fields and put to fire.</td>
<td>This otherwise slow decomposing woody material associated with stall-fed fodder is turned into ashes to fertilize the soil.</td>
</tr>
<tr>
<td>4. Use of first floodwater for irrigation by some innovative farmers.</td>
<td>The first seasonal floodwater is believed to bring organic matter and humus along with it and deposits fine silt on the field and increases soil fertility. This practice is mostly done in paddy fields.</td>
</tr>
<tr>
<td>5. In-situ manuring in the crop fields</td>
<td>This practice involves camping of cattle in the crop fields overnight for some days after the kharif crop harvest. When dung and urine deposition on the fields is considered adequate the camp shifts to other fields. In this practice loss of nutrients and transport labour for FYM from cattle-shed to the fields is saved.</td>
</tr>
<tr>
<td>6. Sowing paddy seeds pre-soaked overnight for nursery preparation</td>
<td>Good germination of these pre-soaked paddy seeds is achieved and irrigation demand for germination is minimized.</td>
</tr>
<tr>
<td>7. Wet soil mixed with seeds of rye (Brassica nigra) is placed inside the holes left between the stones of terrace risers</td>
<td>Minimization of water need for germination and use of the unused space of terrace riser for vegetable cultivation.</td>
</tr>
</tbody>
</table>

Water, which open in adjoining kitchen garden and serve the purpose of minor irrigation. However, of late, people have also started to fix tin / rubber plastic gutters along the sloopy edge of the roof top to guide this water to fall at one corner of the courtyard and also use big polytanks / drums / permanently built small cement-lined tanks to store this water for further use. Sometimes a canal-like carving in the wooden log is permanently kept beneath the roof at the backyard to store rooftop water and for use by cattle.
E. Use of wastewater

(i) The small courtyard of step well (a stone-lined about 1-2 m deep structure to recover seepage water for drinking) is encircled by a stone wall of about 1 m high, so that trespassing cattle do not make the water dirty. Instead an outlet at the base of the wall is left through which the overflowing water from the step well finds its way to an outside pond, which collects water for use by the visiting cattle.

(ii) Wastewater leakage arising from community taps is also stored in earthen tanks dug nearby. Neighbouring innovative farmers use the wastewater stored for irrigating kitchen garden crops. In some villages this water is conveyed to the kitchen gardens by canals/pipes and used alternatively by the neighbour.

(iii) Wastewater generated from the houses is also channeled to kitchen gardens and the ash used for cleaning utensils is considered to have fertilizing effect.

Discussion and conclusion

Traditional adaptation and knowledge are usually indigenous for a given region and include experiences on fundamental understanding of processes of ecological change, slope dynamics and biological conservation. Improvement from one generation to another generation takes place in the traditional practices considering previous experiences (good or bad). Indigenous management of water resources is considered to have built-in eco-friendly system of conservation, preservation and utilization of natural resources also in north-eastern region of India. It has been emphasized that local people, especially where irrigation already exists, have an intimate knowledge of local conditions. Farmers with irrigation experience develop a wealth of knowledge about irrigation requirements for local soils and crops. They often have practical design and experience, which should be essentially incorporated at the time of designing an irrigation scheme. Departmental methods are based on the application of standard rules and criteria, and do not always satisfy farmer’s practical needs, whereas farmers’ attitudes are more flexible and more innovative. A variety of indigenous soil and water conservation (ISWC) practices in many places in Africa consist of all kinds of stone lines and ridge systems to conserve soil and to make the best use of limited rainfall. Concern has now been shown at various levels for this dying wisdom of rich heritage on water management through community participation. Water management practices forwarded by the modern technology often do not prove cost-effective and face difficulties to withstand the dynamic nature of the mountain environment. The social acceptance of such technology is also a constraint sometimes. However, people continue to upgrade the indigenous practices with the modern technological advances only when they find them cost effective and feasible in the bio-physical environment in which they operate. Therefore, a revisit of ISWC practices has started to surface in the thought process of policy makers and programme implementers and finding place as an
important starting point in the soil and water conservation programmes in the central Himalayan region now. There is an urgent need to make a critical appraisal of the traditional knowledge system and how the modern technological advances can be blended for better scientific management of water in traditional agriculture in this region.

Acknowledgement
This study was conducted under a DST funded research project to the authors (Sanction No. SP/SO/A-15/97). Facilities provided by the Director of the Institute are thankfully acknowledged.

References