Institutional Support in Design and Funding of Small Farmer-Owned Irrigation Tanks in the Central Himalayas in Uttar Pradesh, India

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INTRODUCTION

RAPID GROWTH OF minor irrigation constitutes a major achievement of the development planning process in the area of irrigated agriculture. In the grain belt of north and central India large reservoirs of good quality water at shallow depths below agricultural tracts in the Indo-Gangetic alluvial plain have encouraged exploitation of groundwater on an extensive scale. This, along with major irrigation projects has pushed India's food-grains output from a mere 50 million tons to 175 million tons in a period of four decades to usher in what has been acknowledged as a green revolution.

The need to conserve water in rain-fed agricultural lands as well as in forest and range lands in hills is quite obvious. Depleting vegetative cover in common lands and the need to push agricultural activity for an ever-increasing population far into degraded, steeply sloping, and occasionally ecologically sensitive locations have deprived soils of the capacity to retain rainwater in their profile deep and long enough to be available to the plants for sufficient duration as well

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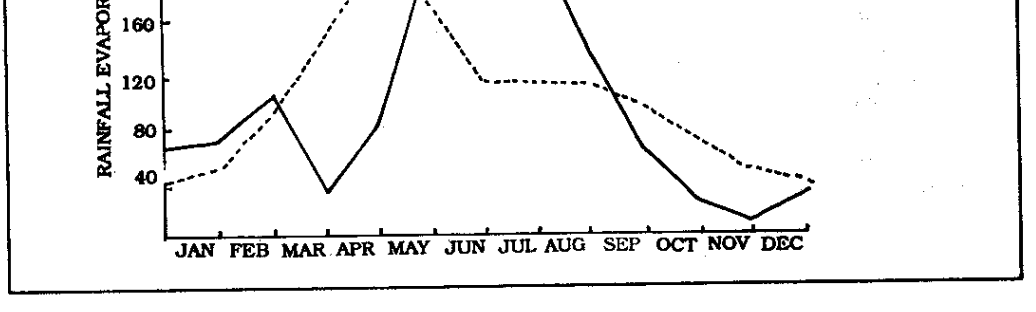
as to provide a constant trickle for downstream use. Valuable soil is being lost everywhere and periods of drought are getting longer. These have greatly reduced returns from agriculture and introduced new strains in the socio-politico-economic fabric in the countryside.

RAINFALL IN THE HILLS

Rainfall in the central Himalayan hill districts in the state of Uttar Pradesh India, henceforth referred to as the hills, is substantial and well-distributed during the year. In most of the area the monsoon rainfall (July-September) is between 100-150 centimeters (cm) and the winter-spring rain (December-March) of the order of 20 cm and above. There are some pockets which experience higher precipitation. Even before the regular monsoons begin in July rains are experienced between April and June. Germination and sprouting of upland (unirrigated) rice and other crops are very much dependent on rainfall during this period of the year which may be the first segment of effective monsoon. For antecedent moisture condition II which is generally to be expected in most of the cultivated area during the monsoon period, sufficient runoff is expected in the meteorological weeks 27 to 34 with somewhat lower runoff in the later weeks. Enough water is thus available for storage and subsequent use during critical dry spells.

Climatic water balance over the year for Almora, one of the cities in the hills (elevation 1,600 meters [m]), indicates that evaporative demand is higher than rainfall in February-May and October-December (Figure 1), and less during the rest of the year. It is in these two periods, respectively, that the filling and ripening stage of winter wheat and monsoon rice crops occur.

Figure 1. Climatic water balance in Almora, Uttar Pradesh (U.P.) hills.



Source: Sharma, B.R. Climatic zones and cropping patterns in U. P. hills.

A study of the monthly soil moisture balance for Almora for 26 crop years showed that the winter wheat crop faces a moisture deficit almost every year (25 out of 26) while the monsoon crop seldom faced it (only twice). A scrutiny of dry spells during the monsoon season indicated that irrigation was required during 8 out of 26 crop years (Sharma 1986).

MINOR IRRIGATION SYSTEMS IN THE HILLS

The seventh Five-Year Plan (1985-90) has specified the need for surface minor irrigation projects with social forestry and contour bunding on a watershed basis, giving emphasis to integration with small headwater tanks for soil and water conservation. The Planning Commission group for hill-area development has said that "the scope of major and medium irrigation being limited in the hills development of minor irrigation is the only hope," and has gone on to stress the need for technological innovation to harness minor irrigation potential. "It may be a low-cost, need-based technology suiting local conditions and upgrading the existing technology" (Planning Commission 1985). Planning of small water-storage projects for drinking-water supply and minor irrigation schemes has been recommended.

Technically speaking, minor irrigation systems include only projects with command areas under 2,000 hectares (ha). None of the millions of farmer-owned tube wells, bore-holes, dug wells, or surface pumping sets under the minor irrigation program command more than 8 ha at the most -- often much less. In the agricultural tracts in the hills minor irrigation systems cover between 0.8-240 ha. A vast majority of these are surface gravity canals with occasional lift schemes comprising electrically driven pump sets or hydraulic rams. Almost all the lift schemes are state irrigation systems. Farmer-managed irrigation systems far outnumber the state irrigation systems, and are smaller in size, and except for the tanks, are now confined only to remote areas in the hills. The design features of the farmer-managed irrigation systems are rather simplistic yet they are fully functional systems and have the additional virtue of being operated and managed by the farmers.

Farmer-managed irrigation systems in the hills can be further subdivided into community-owned and individually owned. Almost all the community-owned systems are gravity canals feeding a whole or a part of a village or a contiguous group of hamlets which may have an interest or right on the main water source. Such interests and rights have been in existence over a long period of time and find sanctity in custom and law. Areas commanded by such systems may range from 2-60 ha.

WATER-STORAGE TANKS

Most of the individually owned farmer-managed irrigation systems use water-storage tanks of varying size, between 6-20 cubic meters (m^3). There are quite a few larger tanks with capacities of 200-400 m^3. Most of these are state-owned except for a few which belong to a religious institution. There is no exact information about the total number of water-storage tanks in the hills, operative or defunct. Based on the achievement of annual targets of the State Minor Irrigation Department during past years, this number has been reported as well over 10,000 in three out of eight districts in the hills (Executive engineer, personal communications 1989). However, up to 40 percent of these tanks have gone out of commission.

The tanks are built in stone masonry using cement mortar. A deficient design, land subsidence, inadequate technical guidance in site selection, lack of supervision of construction, and insufficient resources are some of the causes for the heavy failure rate. Absence of quality control in mortar preparation and lack of knowledge about the need for proper curing to achieve adequate mortar strength accelerate the process of damage leading to shortening of the life span of the tanks. Since it is not possible to provide technical guidance continuously at most places in the remote hill areas increasingly large numbers of tanks become defunct within three to four years of construction.

The importance of and need to build a large number of water-storage tanks in the hills for water conservation cannot be overemphasized. Water management through 1) rainwater harvesting -- storage and conservation, and 2) accumulation of minor perennial flows, so abundantly observed almost everywhere in the hills, can profitably modify the existing land use and cropping patterns. "Water harvesting often provides a useful source of water both in lean rainfall seasons and in low rainfall regions" (Indian Petrochemicals Corp. Ltd. 1985).

Individually owned small tanks provide succor to small crop areas particularly during periods of extreme moisture stress at critical periods of plant growth. Since February-May is a period of adverse climatic balance resulting in poor availability of water, stored water in tanks can be used for one last critical irrigation, and in the event of the tank remaining full even thereafter, for raising nursery rough rice for transplanting in July.[5] Changing requirements of land use for production of fodder and fuel trees will result in maximizing profits, especially from small landholdings, by integrating the social forestry program with water harvesting efforts and at the same time increasing the availability of saplings. Small-sized tanks are ideal for such a program. Thereafter, the production of vegetable and flower seeds, high value spices, and medicinal plants should follow in due course, given the necessary support.

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[5] For the winter-spring wheat crop recommendations under conditions of limited water supply, the following schedule is considered best: 1)Where only one irrigation is possible it is best to apply water at the crown root initiation stage (25-30 days after sowing). Delay at this time results in upsetting the synchronous tillering (particularly in high-yielding varieties), and production of subnormal heads, poor root systems, and poor grain yields. 2) Where two irrigations are available water should be applied at the crown root initiation and flowering stages. 3) If three irrigations are possible, water should be applied at the crown root initiation, late jointing (boot) stage, and milk stage (Sharma 1986).

Size of a tank can be limited by such factors as physiographic features, slope, geology, and seismicity. Fields in the hills are small both in width and area. The unit for land area is a *nali*, which is one-fiftieth of a hectare, and field areas may be as small as 0.1 nali. Most farmers own less than one ha of land and this may be spread in more than one village and scattered in small bits all over a village. This factor alone can limit the size of a tank. A large number of small tanks to fulfill the needs of a village during critical periods cannot be a feasible proposition if the initial cost is high and if they are constructed in good, cultivable land. Common lands may be far removed from both the water source and fields to be irrigated. Large community-or state-owned tanks are likely to be beset with numerous problems of management and operation. Masonry-lined tanks are rather expensive, and making numerous small or a few large masonry tanks can be quite costly, apart from the problem of quality control in construction and other factors limiting their life span.

Assuming that each tank is designed to provide one critical watering of 7.5 cm to an area one-fourth of a hectare in size, the volume of water required works out to 188 m^3. If the tank can be quickly and successively refilled, as in the case of spring-fed tanks so as to continuously irrigate one-third of the area at a time, the required capacity of the tank is 63m^3. Assuming a runoff availability of 20 cm from a catchment of one ha, the yield is 2,000 m^3. With a maximum depth of 1.5 m of water in the tank, its average surface area works out to 42 square meters. Since the fields in the hills are quite narrow a maximum width of six meters at the top can be achieved. In most locations it may be as little as three to four meters. The length of such a tank works out to 10-15 m.

For raising nursery fuel and fodder plants, the water requirement is quite low. Thus, a 10 m^3-tank can support a nursery raising 10,000-15,000 plants with a rural water supply pipeline as its water source.

Water availability. Water for storage in minor irrigation tanks may be available as one or a combination of the following:

1. Stream flow runoff in sizeable quantity for filling a tank in 4-12 hours but not large enough to be transported in a minor channel.
2. Stream flow of small quantity from a spring to fill the tank in 12-48 hours.
3. Rainfall runoff of residential building roofs or roof of the water tank, if covered.
4. Rainwater collected into the tank from a micro-catchment.
5. Storage of return flow from higher terraces.

LOW DENSITY POLYETHYLENE-LINED (LDPE) TANKS

It would be unthinkable for a small farmer in the hills to build a suitably large stone-masonry-cement tank (60-100 m^3). The cost of a properly designed masonry tank works out to an expensive Rs 1,250 to 1,500 per m^3 (currently 1 US$ = 16 Rupees). With the added disadvantage of its short life span, these tanks do not serve any useful long-term purpose.

It is in this context that LDPE-lined tanks appear to have an important contribution to make in storage and conservation of water and its management for agriculture, forestry, and drinking-water needs.

The concept of lining of canals to reduce loss of water through seepage is known and well accepted. LDPE film of varying thicknesses has been established as an effective and economical leakage-preventing material which is being used for lining increasingly large lengths of canals to reduce seepage losses. With LDPE lining the losses can be reduced to one-thirtieth or one-fortieth of that from an unlined surface.

The first LDPE-lined tank in the hills was constructed at Mirtola Ashram in Dhauladevi Block of Almora District nearly 12 years ago. On the basis of experience gained certain modifications have been incorporated in the design of tanks built thereafter. Subsequently, the Vivekanand Parvatiya Krishi Anusandhan Shala (VPKAS) in Almora which is a unit of the Indian Council of Agricultural Research proceeded to design and evaluate small LDPE-lined tanks at their research station at Hawalbagh. Apart from a few tanks at the Mirtola Ashram and the ones built by VPKAS for research work, no headway was made in propagating these tanks. There seems to be non-acceptability of the LDPE tank design at the appropriate governmental levels to entitle them for institutional and governmental financial support. A voluntary organization by the name of Central Himalayan Rural Action Group (CHIRAG) has constructed 14 LDPE-lined tanks in a cluster in a village in Nainital District in the hills and proposes to build a total of 40 such tanks, each of $10m^3$ capacity. This is a part of their action plan for vegetative regeneration of degraded and deforested land in a small area in the hills. Each tank supports a nursery raising 10,000-15,000 saplings of fuel and fodder trees. At least four tanks with water-storage capacity of 100-200 m^3 are included in their ongoing plan (Executive Director, CHIRAG 1989).

Construction of LDPE-lined Tanks

The procedure for constructing an LDPE-lined tank is given below.

1. Water availability must be assessed -- whether rainfall runoff, small spring, return flow, or other source.
2. A suitable site must be chosen: A roof runoff tank will have to be placed near the house/houses from where water is to be collected. Tanks for irrigating fields will need to be constructed so that water reaches the command area by gravity flow.
3. The size and shape of the tank must be calculated: Once the storage volume is known average sectional area is calculated assuming a 1.2-1.5-m water depth. Depending upon the width of the field the surface dimensions of the tank can be determined.
4. The tank pit needs to be excavated to accept the LDPE film lining. The side slopes of the tank need to be calculated for proper workability and stability against slippage. The pit sides and bed are dressed smoothly so that no rock mass or sharp projections are left. Roots of bushes and weeds are taken out.
5. A strong weedicide must be sprayed on the excavated surface.
6. The thickness of earth/other cover needed to protect the LDPE film from damage due to

erosion and impact injury should be determined. Black LDPE films currently in vogue have to be protected from solar ultra-violet radiation and injury by impact or cut. Hence, earth/ other cover on bed and sides is needed. A 2.5-cm layer of fine-screened soil should be put on bed and sides. Alternatively, the surface may be smoothed by trowelling with a slurry of silty clay.

7. LDPE film of adequate strength is laid down and covered with finely screened excavated material on bed and sides. LDPE sheet thickness of 100 micron (0.1 mm or 4 mil or 0.004 inches) is adequate if proper covering is given on top of the film. Even if a much thicker sheet is used it will not appreciably affect the total cost while ensuring higher resistance to root penetration and greater strength against dart impact.

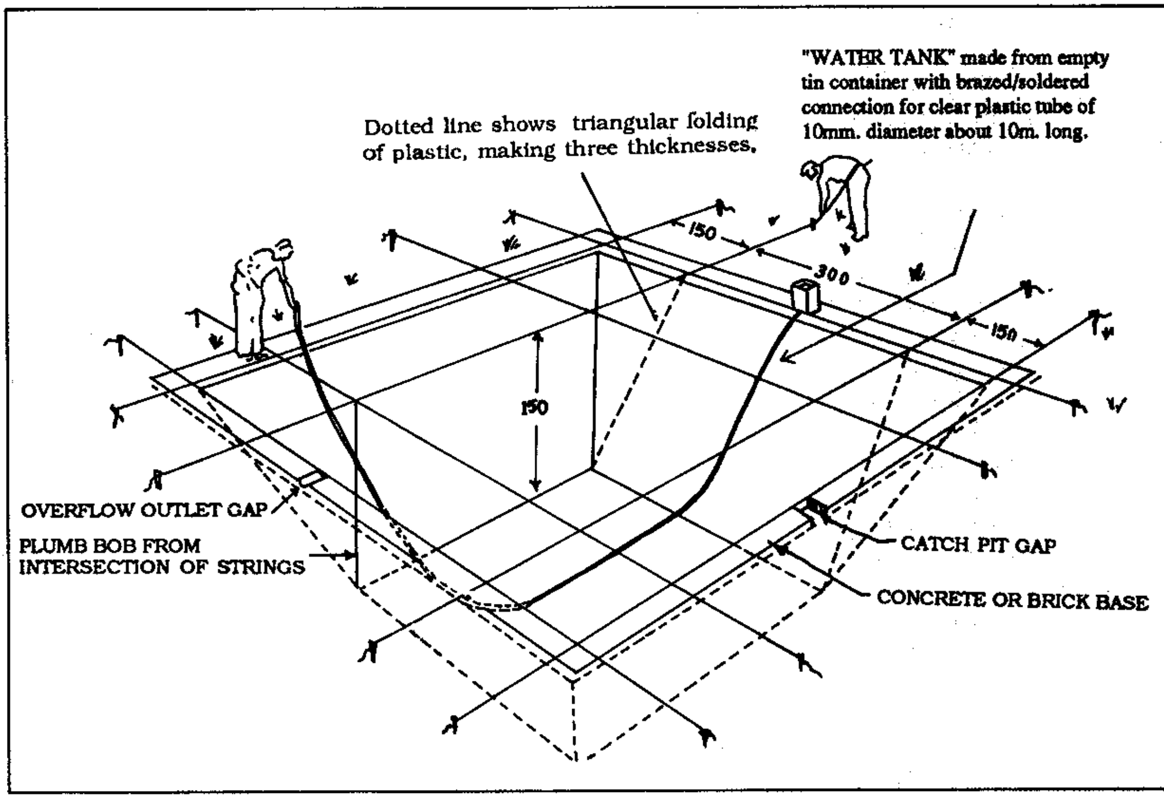
   Soil will remain stable in sides only if slopes are quite flat. In place of soil either stone slabs, boulders, pitching blocks, or sausage-shaped plastic tubes filled with screened earth can be placed either directly on top of the LDPE film or on top of the earth layer. Stone, brick, or concrete block masonry with cement mortar is needed to prevent subsequent vegetative growth through joint cracks which could eventually lead to root penetration.

   The most appropriate method for jointing the LDPE film to achieve large sizes needs to be considered. For the size of tanks proposed in this article the 12 m-wide LDPE film currently available in the market is more than adequate. Large-width sheets can be provided by the manufacturers on order. Jointing together of sheet lengths is very simple, using either the thermal-sealing process, a bitumen-jointing compound, or adhesive tapes.
8. The edges of the sheet need to be securely tucked under and an earth/masonry cover be spread over the anchored portion.
9. The tank should be roofed or fenced to protect the tank from damage and to prevent children and animals from falling into the tank accidentally.

Providing a roof does not help much in reducing evaporation losses. Evaporative loss from water bodies in the hills is not very significant and can be taken care of by spraying harmless vegetable fatty-acid compounds (Anonymous 1989). Evaporation control can also be achieved by 1) using other chemical retardants, 2) controlling parameters that affect the efficiency such as size of reservoir, and 3) compartmentalization. However, the effect of chemicals on aquatic and plant life must be carefully assessed.

Since it is not desirable to puncture the LDPE film to provide outlets for stored water it is best to release water by siphonic action. However, it is possible to provide an outlet at some height above the bed of the tank by folding the film back and jointing the portion properly with the outlet pipe. Figure 2 shows in some detail the construction of an LDPE tank. It is based on the write-up and drawings produced for the Mirtola Ashram tanks. The Planning Institute for the State of Uttar Pradesh has recommended the construction of such tanks on a large scale in the hills because of their low cost and simple construction. The cost of a 10m^3 LDPE tank being constructed by the Central Himalayan Rural Action Group has worked out to around Rs 1,500 (US$95) as against Rs 10,000-12,000 (US$625-750) for a masonry-lined tank of the same size.

Figure 2. Laying out an LDPE-lined tank.



Source: Mirtola Ashram. Write-up on LDPE tanks.

INSTITUTIONAL ARRANGEMENTS FOR FINANCING OF MINOR IRRIGATION

The outlay for minor irrigation programs for the entire country including the program for hill areas as designated in the sixth and seventh Five-Year Plans is given in Table 1.

Table 1. Investment in minor irrigation programs for India.

Investment source	Target amount in million rupees	
	7th Five-Year Plan (1985-90)	6th Five-Year Plan (1980-85)
Institutional investment	35,000	17,000
Public sector funding	28,050	18,110

Source: Planning Commission Seventh Five-Year Plan (1985-90).

In the sixth Five-Year Plan, the actual utilization in institutional investment was only Rs 15,440 million, representing a shortfall of nearly ten percent. The seventh Five-Year Plan has spoken of institutional credit not picking up at the desired pace in eastern and northeastern parts and in many other states due to a deteriorating recovery position. Greater mobilization of resources through the Land Development Bank and commercial banks has been envisaged as a main policy plank for the minor irrigation program.

At the state (provincial) level, the minor irrigation program is implemented by governmental agencies with funds from various sectors of development in the state plan. However, there is a need to coordinate the different programs at the field level.

Under the sectoral program of the minor irrigation department, funds are provided for loans and subsidies to farmers in the hills. Experience has shown that the farmers always repay their minor irrigation loans within the scheduled period, causing no problems in loan recovery (Pande 1987) However, there is almost complete absence of institutional support for minor irrigation programs in the hills. The reasons for this lie in certain structural deficiencies in the entire loaning program of all sectors. Since these deficiencies cannot be overcome immediately other sources for financing and implementation of minor irrigation projects, especially the LDPE tank program, need to be devised.

Lack of appropriate institutions at the village level have hampered the development process including transfer of technology. Those institutions that exist are highly politicized and serve the rural elite only. Voluntary (nongovernment) organizations having no profit motive could act as catalysts for bringing about the necessary attitudinal changes in the hill villages so that new developmental strategies and technologies are accepted and ''people take development in their own hands'' (Planning Commission 1985). A chain of demonstration-cum-replication-cum-training could be established in the process.

Nongovernmental organizations can support the program only up to a point. The pace could be accelerated if private organizations could be encouraged to support the effort. The state government has supported the exploitation of groundwater by allowing cost-free boring up to Rs 3,000 (US$190) for installation of farmer-owned tube wells. A similar subsidy could encourage the construction of LDPE tanks.

CONCLUSION

LDPE tanks hold a great hope for water conservation in the hills for supporting a host of activities in the fields of agriculture, horticulture and floriculture, and social forestry. These tanks are economical and simple to construct and maintenance costs are low. Institutional support for the program is needed so that small farmers can construct them over an extensive area. Nonofficial agencies may be encouraged to participate in the construction of tanks and subsequent training and education of the farmers for the best management of the stored water.

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