Local Adaptations and Basic Designs: An Example from India

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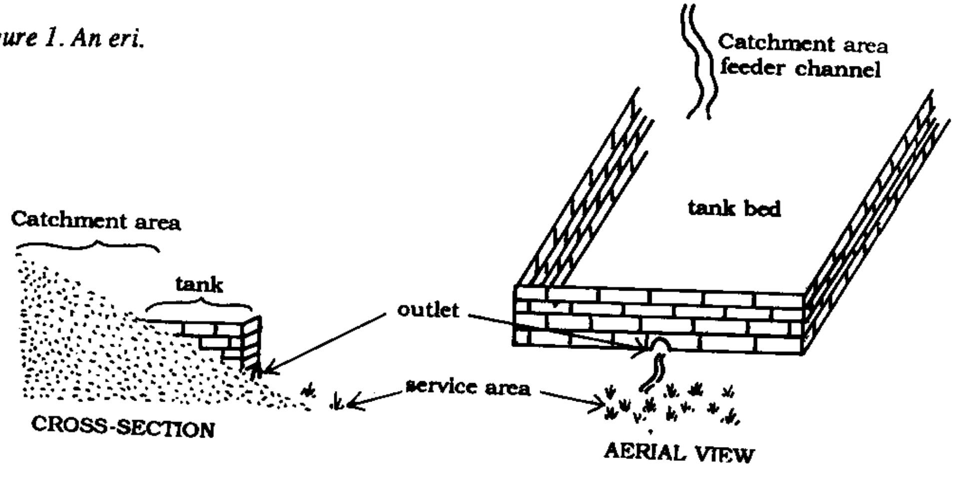
THE INDIAN PENINSULA and its foreland are a very old eroded plateau with a gentle gradient. Throughout this area one finds a distinctive system of irrigation, called locally *ahar*, *eri*, or *keri*. These are three-sided runoff reservoirs providing water for gravity irrigation. In irrigation literature some of these have been named "tanks." However, this is misleading since these are very different from regular tanks (Figure 1). An eri basically consists of an embankment constructed above ground level across the line of drainage on sloping terrain. Two side embankments are then constructed along the line of drainage which lose their height because of the slope of the ground, finally merging with ground level. The fourth side is then left open for runoff to enter. Thus, the eri looks like a three-sided reservoir above ground. Water can be drawn out from the base of this reservoir and used for gravity irrigation of fields at lower levels.

Figure 1. An eri.



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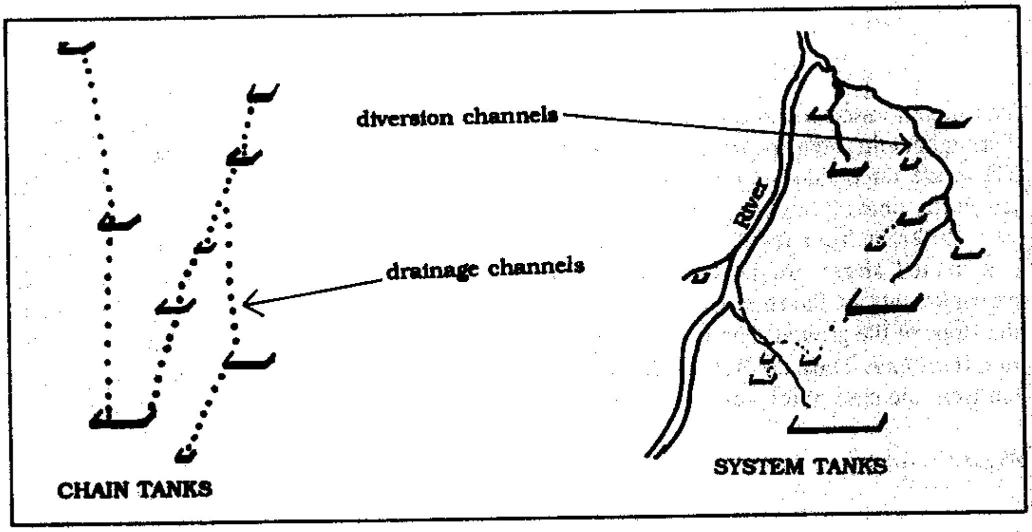
Government reports indicate that there are still thousands of tanks in India which provide irrigation to about 4,000,000 hectares (ha) of land. However, the government statistics are incomplete since it is unknown how many ahars, eris, or keris may have been included or ignored in the count.

A tank with an independent catchment area is called an isolated tank. But the same catchment area may have another tank at a higher elevation which releases its surplus water as runoff that feeds the lower tank. This, in turn, may release its supply to another. Thus, a series of tanks located at different elevations may divide the whole runoff of a watershed among themselves. These are called chain tanks (Figure 2).

Figure 2. Chain tanks and system tanks.



If the runoff takes the shape of a river, that too can be diverted through canals for feeding tanks. In this way a large number of tanks may be supplied by diversion works on a single stream. These are called system tanks of that river (Figure 2). Chain tanks are generally found in the upper catchment area of watersheds. System tanks are confined to the middle lower plains of rivers. Tanks at steeper gradients are small. Those near the coast are usually larger.

A MAJOR FARMER-MANAGED IRRIGATION SYSTEM

A well-designed network of chain tanks and system tanks may utilize every bit of runoff flowing through a watershed above the deltaic plain. When appreciated from this perspective, the whole design could be considered a major irrigation system. Indeed, these tank systems could be an effective alternative to modern multipurpose river-valley projects. Except for the fact that they require a high level of participation from the farmers, their potential as an alternative design for major irrigation projects would be easily acknowledged.

For example, a major multipurpose river-valley project may have a reservoir capacity of approximately one billion cubic meters. It can provide flood protection to about 10,000 square kilometers (km^2) and irrigation benefits to about 100,000 ha. The same effect may be obtained by a network of about 2,000 tanks, each irrigating an area between 15-200 ha. Indeed, the irrigation benefit from tanks would be greater since the total ponded area (about 1,000 km^2) would be dispersed over the whole region, and would provide indirect irrigation benefits through substantial recharging of the aquifer. In addition, farmers could also use the tank bed for cultivation in the dry season since the land retains moisture in the subsoil.

The tank-based design requires the construction and maintenance of nearly 4,000 km of embankment spread throughout the 10,000 km^2 area. This is simply not possible without the involvement of the farmers in the region. Instead, a single reservoir with a 20-km embankment and a central allocation mechanism is far more attractive to both technocrats and bureaucrats.

In India and Sri Lanka there are some districts where all runoff is appropriated in a network of tanks existing since pre-modern times. That other regions did not witness such development or that major rivers were not utilized for system tanks was due to the rudimentary nature of civil engineering knowledge of that time. For modern engineering it is possible to divert major rivers and arrange for interbasin transfer in conjunction with the farmer-managed design. Nevertheless, this is ignored and instead, farmer-managed irrigation systems are being replaced. Every year, thousands of hectares formerly served by these farmer-managed tank systems fall into disuse.

Topographic Adaptations of Chain and System Tanks

In this very old and extensively found type of farmer-managed irrigation systems wide variations in design are observed. A few are described below:

1. The design of the tank is modified to suit the terrain. It is a technique especially suitable to terrain with a gradient of 5:1000 to 1:1000. It is possible that the technique is viable only in arid and semiarid areas, as it is found today only in areas with average annual rainfall of 150-1,000 millimeters. The huge ponded areas may have undesirable effects in high rainfall regions while evaporation loss may have a more serious effect in drier areas.
2. On steeper slopes, tanks are kept small. Because of the high water pressure large tanks may be prone to crack. In areas with gentle gradient larger tanks are viable. Sometimes, tanks are constructed with a main embankment as long as 30 km.
3. Instead of having a rectangular shape tanks are also constructed semicircularly. This probably reduces the thrust of the water over a wider area.
4. In flood-prone loamy soil areas tanks are sometimes provided with embankments within the bed. These partition the tank bed and are provided with outlets to allow the flow of water from one section to another. If one wall collapses, the farmers rush to close the outlets before the other sections are emptied (Figure 3).

5. Sometimes the feeder channels are first impounded in a chamber from which only the overflow reaches the main tank (Figure 4). This may be done to contain siltation. This design was usually found along the margins of arid areas. In general, the feeder channels are left without a scoured passage once they reach the margin of the tank bed.

Figure 3. Sectioned tank.

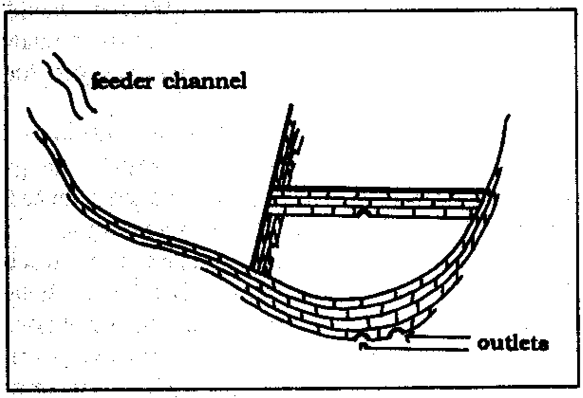
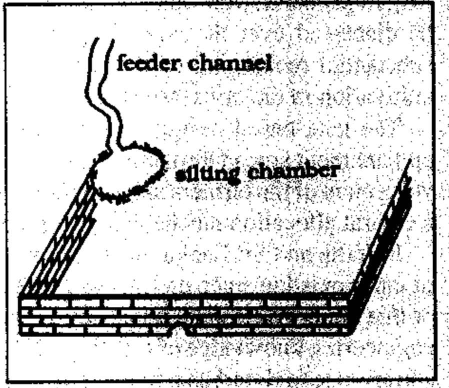


Figure 4. Tank with silting chamber.



6. In arid regions, wells are often dug within the tank bed. These probably act as subsoil reservoirs whereby evaporation loss is reduced. Since tanks also provide drinking water in these areas retaining some water throughout the season is critical.
7. In chain tanks and system tanks the ponded area can be increased by multiple impounding of the same volume of water. It is often found that certain tanks have capacities in excess of their direct service-area requirements. But the reservoir helps recharge groundwater which may be why multiple impounding is very common in drier areas.

AGRICULTURAL ADAPTATIONS SUITABLE FOR FARMER-MANAGED TANKS

The reliability of the water supply rather than the volume of water available is the more important factor which contributes to efficient water utilization. A captive reservoir where the volume of supply is visibly evident allows the water users' maximum flexibility in determining their options for water use. This allows the farmer to have a very high control over the available water supply. A number of agricultural adaptations utilizing the tank resources are described below.

1. Because the captive reservoir enables the farmers to calculate how much water is available for use in the near future they can plan their agricultural and other requirements accordingly thereby reducing the risks of crop losses. In those areas where alternate flooding and drying

of rice fields is followed, a drying operation may be skipped if the water level in the tank is low. If the tank contains insufficient water for normal crop requirements, the farmer group may decide to irrigate only a part of each landholding. Alternatively, the farmers may decide to plant a grain requiring less water in a time of acute water shortage.

2. In most areas the government does not allow the farmers to cultivate on tank beds. However, this practice provides the farmers with an additional option in the few areas where it continues to exist. In times of acute water shortage the water-rich tank bed can be converted to rice fields and the service areas can be used for the cultivation of unirrigated crops. In normal years, in those areas where tank beds are still cultivated, the tanks are emptied after the monsoon season and winter cash crops are sown. During the monsoon season the farmers may also harvest a water-resistant variety of rice from the margins of the tank bed. These are reaped along with two irrigated crops in the service area, the first by direct irrigation from the tank and the second by groundwater irrigation.
3. In very dry areas, in a year of drought, the farmers may decide to use only water from shallow wells in their fields and not undertake gravity irrigation. The scanty supply in the tanks is left for the use of livestock.

In arid western India, in those parts where cultivation of tank *(khadin)* beds is still possible there are a number of examples of systems where the agricultural irrigation options described above are practiced. If rainfall is very high the service area outside the tank is irrigated by gravity flow. If rainfall is normal only percolation from the tank is used in the service area. When rainfall is far below normal the tank bed is used for cultivation. This array of options helps the farmers to adapt to a wide range of rainfall variation from year to year.

CONCLUSION

Tanks for irrigation and other purposes -- drinking water supply, water for livestock, flood control, fisheries, and control of soil erosion and salinity -- are a viable option for improved conservation and utilization of water resources. All these farmer-managed irrigation systems in a catchment area could be developed into spatially well-planned systems that should be regarded as potential major irrigation systems.