TANKA-A RELIABLE SYSTEM OF RAINWATER HARVESTING IN THE INDIAN DESERT

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Introduction

Water is the most precious commodity in the arid regions due to prevalence of unfavourable hydrometeorological conditions. In western Rajasthan, particularly in Barmer district, the quantities of water available from various sources such as surface water and groundwater are not sufficient even for drinking purpose. Over and above the insufficient quantity, the groundwater is moderately to highly saline over a large area. For nearly 76 per cent of the area of the district, the total dissolved salts (T.D.S.) in ground water range from 1500 to 10,000 ppm. For survival under such conditions, people have been depending on rainwater harvesting (RWH) in the form of small ponds (*Nadis*), reservoirs, underground tanks (*tankas*), *Khadins* etc. either for drinking purposes or for agriculture, since time immemorial.

The people of the district, by and large, reside in scattered settlements (*dhanis*) particularly in the western, north-western and southern parts where sand dunes, interdunal plains and undulating sandy plains are the dominant land forms. Under such conditions it is inconceivable that organised and costly water supply schemes will be a feasible proposition to fully meet the drinking water requirements of the human and livesock populations. Therefore, in this area, the traditional techniques of rain water harvesting developed by the local people, mainly *nadis*, *tankas* and *beries* have to be developed. Such systems provide convenient, moderately clean and sweet water for drinking which eliminates the need to scavenge for water in the hot months. Out of the different forms of rainwater harvesting stated above only *tankas* will be discussed in this monograph.

2. History of tanka

The history of marwar reveals that the rainwater harvesting practice in the form of *Baoris* and *talabs* was much earlier than of *tankas*. Rao Jodhaji constructed a *talab* (Ranisar) near Jodhpur fort during 1520 A.D. (Marwar Ra Pargana Re vigat, part - I). The first known construction of *tanka* in this region was during the year 1607 A.D. by Raja Sursinghji in village Vadi ka Melan. Further in the Mehrangarh fort at Jodhpur a *tanka* was constructed during the regime of Maharaja Udaisinghji in the year 1759 A. D. However, during the great famine of 1895-96 the construction of *tankas* was taken up on a wider scale in this region.

3. Benefits of tanka

Rainwater harvesting in a *tanka* offers the advantages of private ownership without losing economics of size. This means that for drinking needs these are to be based on individual household facilities. However, if such a facility is provided on a community basis it needs the cooperation of all concerned to operate it in a similar way as they operate wells. Under circumstances when the source is publicly owned, gets filled to an unpredictable level, it is more often than not that the villagers find it too tempeting to use it optimally. Water is used up at a fast rate and in the end the people demand a somewhat more durable source of water. Our experience in the desert areas suggests that imposition of control over water rights should ensure orderly use of water. The benefits of *tanka* are usually listed as:

1. Time - saving, particularly for women fetching water
2. Improves health of productive workers
3. Benefits consumers in terms of taste, cleanliness, quality, etc.
4. Improves self reliance of the rural people
5. Stabilises rural employment and skills
6. Saves time and effort, especially for older people for whom a 10-15 km round trip with a donkey, camel, or bullock cart may be the only other alternative for meeting their water needs.
7. Offiers a valuable supplementary source of water when bore holes run dry, pumps fail or fuel runs out
8. Improves the living standard of the people of an area poor in groundwater resources, and
9. Is a cheaper alternative to a much more costly piped water supply scheme.

4. Present status of tankas

The people of this region have developed the *tanka* system to harness rainwater for meeting part of their daily requirements. During the past two decades, the Rajasthan State Government, as a part of its development efforts, has extended this system among smaller communities of people. Practically evey *dhani* now has one or more *tanka* for rain water harvesting mainly for drinking purposes. According to their economic conditions, people of this area have devised their own methods for constructing these structures, but still there is a lot of scope to improve them. Looking to the present status, it is obvious that the *tanka* system does not ensure an adequate supply of water tnroughout the year; this is mainly due to the meagre rainfall and inadequate catchment areas left for harnessing the runoff. On investigations, it has been found that the availability of water in a *tanka* ultimately depends on rainfall, supplemented with the type and size of the catchment area. The catchment areas are artificially prepared with pond silt treatment. Essentially, providing a catchment area for runoff should be sufficient for the required quantity of water from a lean rainfall year. But, here the ratios between the treated catchments and the probable runoff from lean rainfall years have not been maintained, due to which most of the *tankas* fail to meet the annual requirement of drinking water for the human population. The catchment areas are now meant to generate runoff to the full capacity of *tankas* only during above normal rainfall years.

4. 1 Size of tanka and construction materials

Tankas constructed on individual *dhani* basis are circular in shape having almost similar depth and diameter, varying from 3. C0 to 4. 25 m. Since stone, as building material, is not available at all places in duny areas and as it is relatively costly, only two types of materials are at present being used in the construction of *tankas.*

(i) Only lime plaster and cement plaster

After completion of excavation of earth work in the required shape and dimensions, lime mortar is used to plaster bare horizontal and vertical soil surfaces to the thickness of about 6 mm. A second layer of plaster of cement mortar is applied to a thickness of about 3 mm. The top is covered with *Zizyphus numularia* thorns (fig. 1). Simple lime plastering of the bare soil surface makes the useful life of a *tanka* limited, to the maximum extent of 3 years. In many cases of lime plastering only, the retention of water is also low due to the development of cracks in the plaster.

(ii) Cement concrete

In a few cases, the *tankas* have been built by using cement concrete in the floor ing and in the construction of the circular walls. This type of material ensures a life span of 10-15 years for the *tankas.*

4.2 Preparation of catchments

The catchments of *tankas* are made in a variety of ways using locally available sealing materials The generally used materials are pond silt, murrum, woodcoal ash, gravel, etc. The size of the catchments may vary from about 20 m^2 to 2 ha depending on the expected runoff and the availability of spare land. The surface sealing materials are used in the following ways :

Pond silt - After clearing the soil surface of vegetation, the land is given a smooth gradient of 3 to 4 per cent slope towards the *tanka.* On this cleared surface the pond silt obtained from nearby dry *Nadi* beds, is spread in a 3-4 cm thick layer. During the rainy season, after the first shower, this layer is compacted and made semi-impervious by a local compaction technique. The technique consists of rolling of *Crotalaria burhia* and sand. The roller technique is applied every year at the onset of monsoon.

Murrum - At places where a calcium carbonate concretion zone occurs below the soil surface at shallow depths (1. 5 to 3 m), the water proofing of soil is done through the use of these concretions locally known as murrum. After clearing the soil surface of vegetation, a thin layer (5-7 cm) of murrum is spread over it. At the onset of monsoon, sheep and goats are made to move over the murrum again and again till the surface is compacted and becomes semi-impermeable. During this process water is also sprinkled, if needed. This technique is applied every year to strengthen the *tanka* catchment.

Wood coal ash - Although wood coal ash is not used as the sole surface sealing material, yet it is used to repair the catchments made up of pond silt and murrum locally. The ash settles, fills the pores and makes the surface water proof.

Gravel - In certain areas, where rock exposures occur, the *tanka* catchments are made up of 15 to 20 cm thick compacted ballast layers. However, such type of catchments are limited in distribution, depending on the availability of gravel.

5. Improved design of tanka

5. 1 Rainfall

The average annual rainfall in Barmer district is 264 mm with a westwardly decreasing trend. In the eastern part of the district, in Siwana *tehsil*, the average annual rainfall is 344 mm while in Sheo *tehsil* (northwest) it is 208 mm. Most of the rainfall occurs in the hot monsoon period i. e., July to September. The average number of rainy days (more than 2. 5 mm per day) in a year varies from 10 to 15 Based on the available rain fall data from the Indian Meteorological Department for 50 years period 1901-50 it has been inferred that the maximum rainfall for ten years return period is about 125-150 mm while 50-75 mm of rainfall can be expected once in two years (Anonymous, 1971).

5. 2 How much water ? Technical versus Economic efficiency

It is simple to calculate the annual water needs of the people. Say a family consists of 6 persons; a minimum per capita per day requirement of 7 litres of water is usually considered by the villagers to be the bare minimum that one has to have to live without distress. Clearly, a family needs 1.302 m^3 of water per month and requires 15. 624 m^3 or say 16 m^3 of minimum storage to survive throughout the year solely using *tanka* water. However, in the case of unusual consumption of drinking water of say 14 lit per capita per day during the summer period of 4 months, an additional provision of 5 m^3 of water has been provided in the storage capacity of *tanka*. Therefore, it may be optimal for a project to erect *tankas* of not less than 21 m^3 in volume though the unit cost of construction of *tankas* of such capacity is nearly 1. 5 times greater than *tankas* of larger capacities, say of 200 m^3, yet economising on the construction will be a false economy if it leads to an unproductive use of water. Generally, people use more water as more becomes available.

A number of published material is available which seems to be in favour of the construction of storage *tankas* of smaller sizes for individual households in different countries. For example, tanks of 2.5 m^3 capacity have been constructed in west Java for individual households, which are, of course, too small (Doelhomid, 1982), but the local people are apparently against the communal alternative of 10 m^3 tanks for 4 households. Van Verkvoorden (1982) has mentioned a few references to indicate individual and government enterpreneurship in the tank building field. Winarto (1982) noted the importance of private ownership of small sized tanks, especially as their maintenance is easier. Molvaer (1982) concluded that the distributed tanks in *kenya* are a great success with the people living in the area. Some other advantages of tanks meant for individual households are enumerated as follows :

(1) In case of community storage tanks, the dominant groups get individual supply to their homes which the poor do not receive;

(2) Access to the new water supply might be monopolised. This

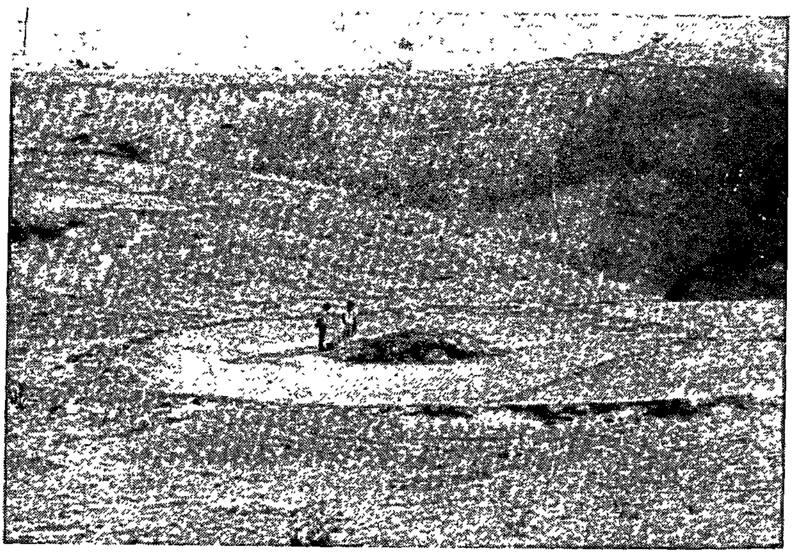


Fig. 1. Local practice of *tanka* construction.

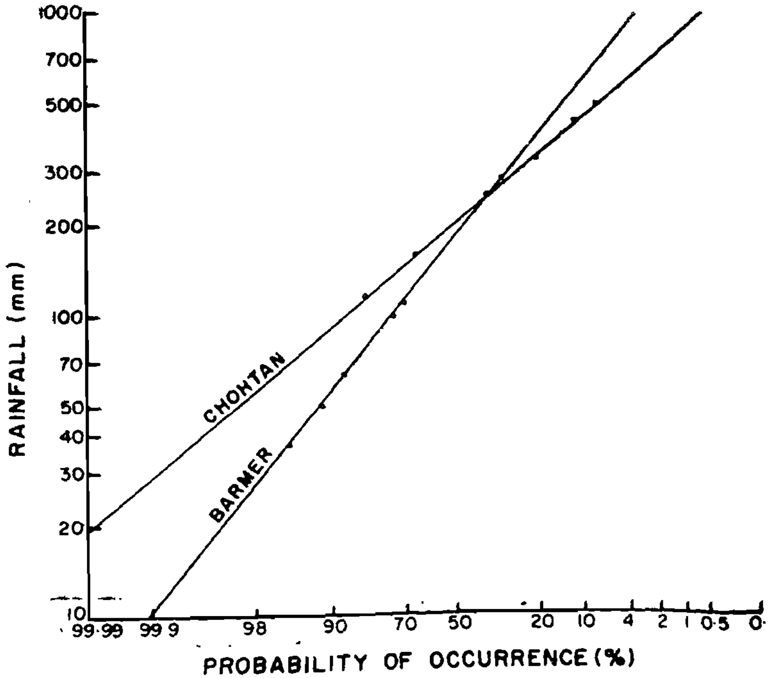


Fig. 2. Rainfall probability at chohtan and Barmer *Tehsils* (besed on 1961-86)

danger includes cases where the design of the project appears to cover the poor people of the scheduled castes, while the actual flow is limited and only the dominant groups get the benefits;

(3) Community tanks have generally failed through poor workmanship and high costs;

5. 3 Suitable design of tanka

A *tanka* is usually circular or retangular in shape. The circnlar *tanka* is the most economical form of the structure and is found to be more stable as the pressure exerted by water is uniform radial pressure in all directions in the diametrical plane at right angle to the curved surface.

The successful installation of a *tanka* depends on the selection of site, particularly the catchment characteristics such as size, shape, topography, soil type, vegetation, etc. The size of the catchment selected, or artificially prepared should produce adequate runoff to meet the storage requirement of the *tanka* and at the same time it should cause minimum soil loss. Experience indicates that a 2 ha catchment, having 2 to 3 per cent slope, on gravelly or heavy textured soil free from vegetation, is generally sufficient for a *tanka* of 200 m^3 capacity. (Prajapati et al, 1973). However, the size of the catchment area depends on dependable rainfall. For different *tehsils* of Barmer district, the probability curves obtained from mean annual rainfall are given in Fig. 2 and 3. The dependable rainfall has been taken as annual rainfall occurring at 60 per cent probability worked out through the Log Pearson Type III Distribution and is based on 23 years' data (1964-86). Accordingly, the catchment area required for two types of *tanka* in each *tehsil* is given in Table 1. The catchment area has been worked out by the equation :

$$A_c . P_d . C = m.d. A_o \qquad (1)$$

where, A_c is catchment area. P_d is dependable rainfall, c is runoff coefficient = 0.20, m is storage coefficient - taken as unity for the *tanka*, d is the depth and A_o is the cross sectional area of the *tanka*.

The mean annual rainfall is the lowest, viz. 187 mm in Sheo tehail, whereas the maximum of 321 mm is in Siwana tehsil. The rainfall probability at 60

Table 1. Design parameters for *tanka* in *Barmer* district.Western Rajasthan, India.

	Tehsils				
	Barmer	Sheo	Chohtan	Siwana	Pachpadra
1. Mean annual rainfall, mm	266	187	233	321	214
2. Dependable rainfall, mm (60% of probability)	148	134	175	253	146
3. Catchment area m^2 per m^3 of runoff	34	37	29	20	34
4. Catchment area, m^2 for 200 m^3 capacity *tanka*	6800	7400	5800	4000	6800
5. (i) Catchment area, m^2 for 21 m^3 capacity *tanka*	714	777	609	420	714
(ii) and diameter, m	30.2	31.5	27.9	23.1	30.2

per cent of the mean annual rainfall varies from 134 to 253 mm in the different *tehsils*. Accordingly, the required catchment area per m^3 of runoff worked out to be 20-37 m^2.

After selection of site and size of the catchment, it is imperative to carry out some minor treatments in the catchment for augmenting runoff. These treatments may be such as construction of earthen diversion bunds, removal of vegetarion where practical, increasing the land slope, compacting the soil, spreading and ramming of a layer of murrum or silt-clay which results in reduction in the intake rates of the soil.

5.4 Constructional details

The constructional details are given in Fig. 4 and 5. However, special emphasis have to be given on the following aspects.

Special care is required to ensure against any cracks and leakage from the floor and walls of the structure. This can be achieved by providing a sufficiently thick (22 cm) cement concrete flooring and a 12-15 mm thick cement plaster on the walls, incorporated with water proofing compounds, or with one per cent soap solution in water (soap soluation forms insoluble fillers on reaction with cement). Proper cementing of joints in the super structure should also be eusured, especially when further construction on a half finished work is resumed after the lapse of a few days.

The inlets and outlets in a *tanka* should be placed 3 cm below the ground level and must be provided with vertical iron bars, 5 to 7 cm apart and expanded metal to prevent entry of floating debris, and birds and reptiles etc. which attempt to approach the water, usually drop inside the *tanka* and spoil the water.

In the case of 200 m^3 *tanka*, silt collecting gutters have been found to be very effective in settling down the suspended sediment and preventing small poisonous insects like scorpions, ete., from entering the *tanka*. The inward sloping cement concrete apron around the *tanka* with about 3 per cent slope helps in collection of even meagre runoff. The masonry checkwall about 50 cm high constructed across the apron also helps the water to enter into the *tanka*. Although it may not be absolutely necessary, thorn fencing may be provided around the catchment area to minimise pollution of the *tanka* water with livestock wastes and other dirts.

5.5. Maintenance and After care.

At least once in a year cleaning of a *tanka*, ramming of its catchment, and painting of the inlets and the outlets is a must for keeping the *tanka* in good condition. Also desilting of the *tanka* is necessary, and may be taken up before the onset of the monsoon. Periodical use of oxidising agents like potassium permanganate will prevent the growth of microscopic organisms, and development of bad taste, odour and colour of the water. Alum helps in settling the dirt in suspension. At least a few cm of water column should always be maintained in the *tanka* to avoid development of cracks, etc.

CONCLUSION

The study revealed that the traditional practice of water harvesting in the form of *tanka* must have played an important role in meeting the drinking

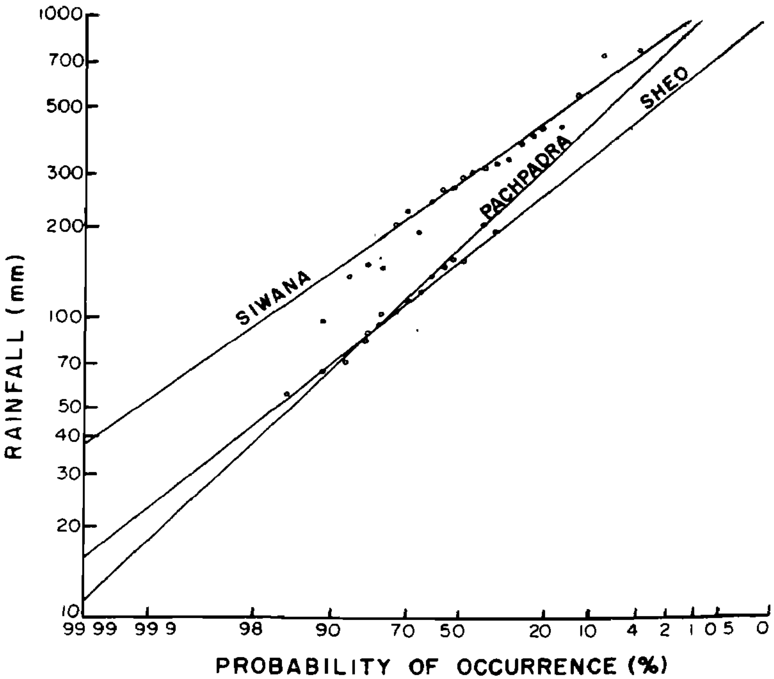


Fig. 3. Rainfall probability at Siwana, Pachpadra and Sheo (based on 1961-86)

CONSTRUCTIONAL DETAILS OF A WATER TANKA FOR A SINGLE FAMILY (CAPACITY 21 Cu. M)

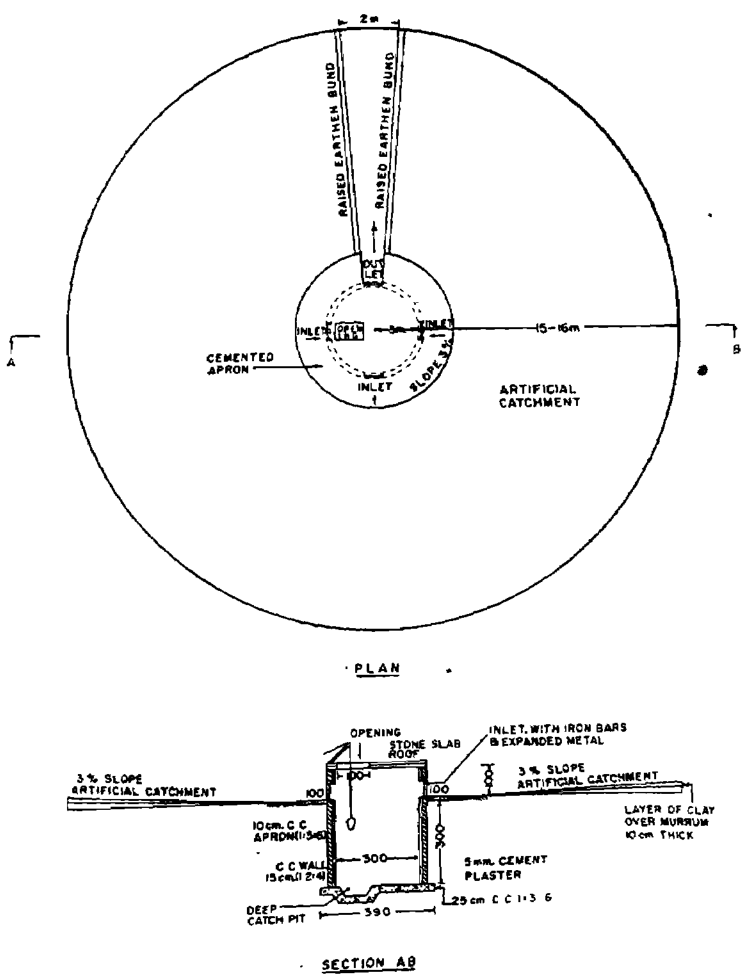


Fig. 4.

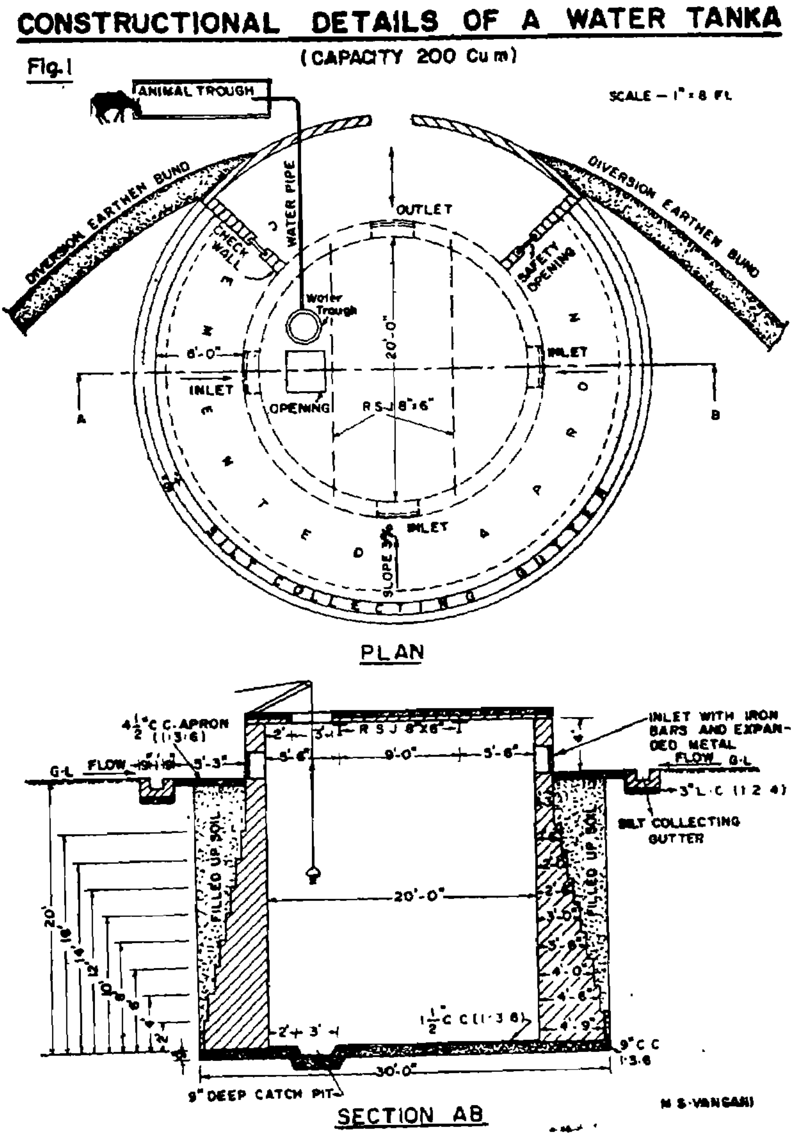
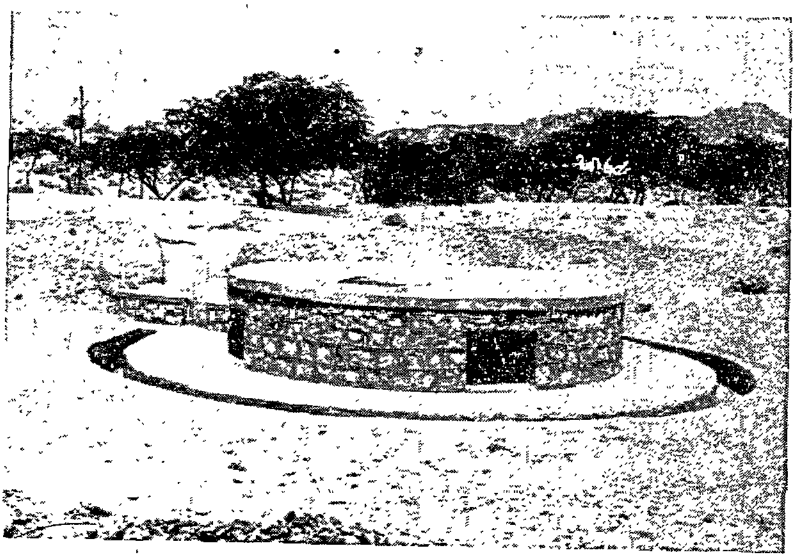

CONSTRUCTIONAL DETAILS OF A WATER TANKA
(CAPACITY 200 Cu m)
Fig. I
ANIMAL TROUGH
SCALE – 1" = 8 Ft.
DIVERSION EARTHEN BUND
DIVERSION EARTHEN BUND
WATER PIPE
OUTLET
CHECK WALL
SAFETY OPENING
Water Trough
20'-0"
6'-0"
INLET
INLET
OPENING
R S J 8"x6"
A
B
INLET
SLOPE
SILT COLLECTING GUTTER
PLAN
4 1/2" C C APRON (1:3:6)
INLET WITH IRON BARS AND EXPANDED METAL
G·L
FLOW
5'-3"
R S J 8"X6"
5'-6"
9'-0"
5'-6"
FLOW G·L
3"L·C (1 2 4)
SILT COLLECTING GUTTER
FILLED UP SOIL
FILLED UP SOIL
20'-0"
1 1/2" C C (1:3:6)
9" C C 1:3:6
30'-0"
9" DEEP CATCH PIT
SECTION AB
M S VANGANI

Fig. 5.



Improved *Tanka*.

water requirement of the desert people in the past. However, at present the *tanka* alone is not capable of meeting the increased demand for drinking water of the burgeoning population.

It can at best be viewed as an important component of an integrated drinking water supply scheme involving other water sources viz., well, pipeline supply, *nadi* etc. Hence, *tankas* will continue to play an important role now and in the future to meet the drinking water demands of the rural populace, especially for people living in scattered *dhanis*.

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APPENDIX

6.1 Estimated cost of a *Tanka* capacity 200 m^3. (For Schools, Hospitals, Dispensaries, Panchayatghars, etc)

S. No	Particulars	Quantity	Rate		Unit	Amount Rs.
1.	a. E/w in excavation in ordinary soil other than blown sand like vegetation or organic soil, turf, sand silt loam, mud, peat or mixture of those of and similar material (yield upto the ordinary application of shovel phawarh rake or other ordinary digging implement) complete with lead upto 25 m and lift upto 1. 6 m	427.4	cum	4.20	cum	1795.08
	b. Add extra of additional lift of 1.5 m for 1.5 to 3 m	100.13	cum	0.60	cum	60.08
	c. -do- for 3 m to 4.5 m	100.13	cum	1.20	cum	120.15
	d. -do- for 4.5 m to 6 m	155.15	cum	1.80	cum	207.27
2.	(a) P. & L c. c. (1:2:4)	1.48	cum	125.00	cum	185.00
	(b) P. & L c. c. (I. S 456) 1978 m 10 (1:3:6) grade with crusher broken grit maximum size 20mm or below by means of manually	19.6	cum	41.50	cum	8134.00
3.	C. R. stone masonary in lime sand mortar mix (1:2)	134.21	cum	152.00	cum	20399.92
4.	S & F. R. S Joists 8" x 6"	.600	kgs	8.30	Kg	4980.00
5.	P & L Soor sagar white stone patty	35.85	sqm	40.00	Sqm	1434.00
6.	(M_{15}) c. c. (1:2:4) flooring with crusher broken chips of required size without glass strips in joints complete 25 mm thick.	35.85	sqm	15.00	sqm	537.75
7.	25 mm thick cement bajri plaster (1:3) ratio finished with flooring neat cement	701	sqm	22.00	sqm	15422.00

S No	Particulars	Quantity	Rate	Unit	Amount Rs.
8.	S & F 0. 71 mm thick 228 w. g. C. G. I sheet door in L iron frame 40 x 40 x 6 mm. Suitably braced with flat iron 40 x 6 mm including rivets/bolts/nuts/hooks etc. complete with red oxide/equivalent paint 2 coats	1.12 sqm	300.00	sqm	366.00
9.	S & F. including fabrication of plain bars/other plain grills welded to steel frame for inlet and outlets	4 nos	L. S	50/- each	200.00
10.	S & F angle iron frame with pully	1 No	L. S.		300.00
	Note: The rates are based on PWD BSR of January 1986				
			Total		54111.25
			Say		55000.00

Annual cost analysis:

1.. Cost of structure Rs. 55000 00
2. Life of structure 20 Years
3. Depreciation i. e Amortization 1. 5% per annum

$$ACRF = \frac{i(1+i)^n \times c}{(1+e)^n - 1}$$

where $i = 0.015$
$c = 55000$
$n = 20$

$$\text{Therefore, } ACRF = \frac{0.015(1+0.015)^{20}}{(1+0.015)^{20}-1} \times 55000$$

$= \text{Rs. } 3209.39$

Cost of Construction	Cost toward amortization	Annual operation cost	Maintenance cost @ 2%	Annual interest @ 10.5%
55000.00	3209.39	Nil	1100.00	5775.00

Total annual cost Rs. 10084.39
Hence the cost per cum of water Rs. 50.42
i.e cost per litre = Rs. 0.05

6.2 Estimated cost of construction of tanka 21.00 cum. (For individual families)

S.No.	Particulars	Quantity	Rate	Unit	Amount Rs
1.	Earthwork in exacavation in tank and apron	34.883 cum	5.00	cum	174.42
	a. add extra for lift beyond 1.5 m	12.912 cum	0 60	cum	7.74
	(i) 12-912 cum (ii) 3.673 cum	3.673	1.20	cum	3.62
2.	a. clay layer over murrum	30.806 cum	5.50	cum	169.43
	b. Transportation with lead at 4 km	30.806 cum	14.20	cum	437.45
	c. Loading and unlding charges	30.806 cum	4.75	cum	146.32
	d. Labour charges for spreading to proper grade L.S				200.00
3.	Cement concrete (1:3:6) at base and apron (3.212 + 1.354) = 4.565 cum	4.566 cum	415.00	cum	1894.89
4.	Cement concrete wall (1:2:4) or stone masonry in cement mortar (1:6)	6.035 cum	540.00	cum	3258.90
5.	Stone slab roofing	7.608	110.00 m		836.88
6.	Opening with iron bars and expanded metal	4 Nos	100	1 No	400.00
7.	Mis. items like G.I. sheet cover etc L.S		L.S		400.00
				Total	7929.65
				say Rs.	8000=00

Note : The rates are based on the PWD BSR January, 1986

Annual cost analysis :

1. cost of structure — Rs. 8000
2. Life of structure — 20 year
3. Depreciation i.e Amortization — 1.5 % per annom

$$ACRF = \frac{i(1+i)^n \times c}{(1+i)^n - 1}$$

where $i = 0.015$

$c = 8000$

$n = 20$

Therefore, ACRF = 0.015 (1 + 0.015) 20 X 8000
(1 + 0.015) $^{20-1}$

= Rs. 466.82

Cost of construction	Cost towards Amrotization	Annual Operation cost	Main tenance cost @ 2%	Annual interest @ 10 5%
Rs. 8000.00	Rs. 466 82	NIL	Rs. 160.00	Rs. 840.00

Total annual cost = Rs. 1466.82
Hence the cost per cum = Rs. 69.84
i.e cost per litre = Rs, 0.069
Say Rs. 0.07

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