Working Paper No. 155

Potable Water for the Rural Poor in Arid Rajasthan: Traditional Water Harvesting as an Option

Keshab Das
Pritee Sharma

Gujarat Institute of Development Research
Gota, Ahmedabad 380 060

March 2005

Abstract

Traditional water harvesting systems (TWHS), generally neglected, have come to be recognized as an important source of potable water, especially in the arid and semi-arid regions of India. Increasing instances of failure of modern piped-water schemes plagued by unreliability, inadequacy and improper maintenance have prompted promoting TWHS as useful sources that prevent groundwater exploitation and serve as security during monsoon misses. This paper enquires into the potential of wells (as TWHS) in the Thar desert area of Rajasthan. Following a detailed analysis of hydrological and structural aspects of the source and quality of water, the paper presents results of intensive field surveys conducted in two villages in the districts of Jodhpur and Barmer. Given the pattern of water use and dependence upon alternative sources for drinking and domestic purposes, the households' willingness to pay for reviving/ modernizing TWHS and piped system has been analysed in comparison. An important insight gained is that desilting and developing local surface water sources, although more expensive so far as capital cost is concerned, is preferable over piped water supply from elsewhere. While very poor households would, naturally, decline to share the capital costs for an improved water system, their willingness to contribute labour and O & M costs suggested value attached by the local community to TWHS as sustainable sources of potable water in arid regions, at least. Whether and how the state can intervene and shall seek private participation, both in financing and providing technical and management support is an issue that needs probing.

JEL Classification : ***Q25 and I31***

Keywords : ***Traditional water harvesting systems; Rural poverty; Water scarcity; Cost comparison; Thar; Rajasthan***

Acknowledgements

This paper is based on a part of a larger study on traditional water harvesting systems in western India (Das, 2003), which was sponsored by the Environmental Management and Capacity Building Project, through the Ministry of Environment and Forests, Government of India. For many useful suggestions and advice, subject experts and members of the Environmental Economics Research Committee, especially, Jyoti Parikh, Paul Appasamy, K.K Narang, Maria Saleth, Robin Mukherjee, Kirit Parikh and Sudarshan Iyengar deserve thanks. Special thanks are due to the academic referee, R.N. Athavale, for excellent comments on the draft of this working paper.

For useful suggestions we thank Anupam Mishra, Dinesh Kumar, Vinish Kathuria, Amalendu Jyotishi and participants, especially, Mihir Shah, Surjit Singh and R.S. Deshpande, at the Ford Foundation and GIDR organized seminar on 'New Developmental Paradigms and Challenges for Western and Central Regional States in India' where a preliminary version of this paper was presented. Help received during the difficult field surveys from Bharat Bhati, Binja Ram, Dalpatbhai, Pemparam Barupal and, importantly, Ganibhai Memon is gratefully acknowledged. Engineering and hydrological consultancy provided by N.A. Ansari, Y.S. Patel and Atul Merh was of much use.

None, however, is implicated for any shortcomings that still remain.

Potable Water for the Rural Poor in Arid Rajasthan: Traditional Water Harvesting as an Option

Keshab Das
Pritee Sharma

1 Introduction

With growing instances of government-sponsored modern piped water systems unable to supply adequate quantity of water on a regular and reliable manner, at least in the rural areas, sustainable access to potable water has clearly emerged as a serious problem in many parts of the country, irrespective of the rainfall received in these regions. Relentless withdrawal of groundwater to feed to the state water supply programmes is no longer seen as a viable means of addressing the water needs for rural households (Das, 2001). This is especially the case in arid and semi-arid regions where both low and fast-declining groundwater levels have been threatening livelihood options and future demand for the precious resource. The present study, in fact, focuses on the analysis of primary evidence obtained from rural areas of the Thar Desert region, unarguably the most arid belt of the country.

Further, in the public policy sphere, particularly since the early 1990s (if not before), there has been a *pronounced* paradigm shift through 'reforming' the drinking water sector. In practice, however, this new strategy, emphasising user financing and local management as key to efficient utilisation of potable water, faces its most notable hurdle of inadequate or no recovery from the very poor rural households. Despite the soundness of the 'efficiency' argument, payment for capital expenditure by individual households in poverty remains a complex issue to tackle. The crux of the matter, certainly, remains enhancement of supply *per se; inter alia*, such an effort would contribute towards a lower price level of the resource.

Towards supply augmentation on a sustainable basis, a number of alternative mechanisms of water collection, storage and management have been tried out, often by para-statal bodies, including local communities in certain places. A particularly strong engagement has been with what are known as traditional water harvesting systems (TWHS). As the name suggests, these systems, the very many varieties of them, have been in use for centuries and, essentially, been based on tapping surface water (monsoon run-off, rivers, or streams) and/ or rainwater[1]. Apart from being hailed as 'great' techniques devised in consonance with the local environment (including, hydrology and topography) and socio-cultural specificities, these systems helped recharging groundwater, fulfilled local demand for the resource and, above all, could be sustained for a great length of time.

The re-emergence of interest in the TWHS has, *inter alia*, certainly been prompted by the falling groundwater tables in most regions due to overexploitation, contamination and failure of regular monsoons. Instances of potential of these structures in collecting and storing huge quantities of potable water in such arid and rain-starved regions as Rajasthan, Kutch and Saurashtra regions of Gujarat, south western Madhya Pradesh and arid tracts of south India have come to be documented widely during the last over a decade or so. These include Mishra (1993 and 1995); Agarwal and Narain (1997); Vaidyanathan (2001); Agarawal *et al*, (2001); Bhagyalakshami (2001); Reddy *et al*, (1992); Bishnoi (2000); Sridhar (2001) and Barah (1996). Impressed with the performance potential and ingenuity of TWHS, some protagonists have even gone to the extent of placing the entire faith on these, convinced that the modern piped water systems are a waste of resources and lack sustainable, people-oriented technological back-up.

Despite the enthusiasm generated by the TWHS, a few serious limitations are associated with these. A particularly disturbing aspect is that most of these systems have fallen to disuse either due to structural deficiencies or human neglect. Even, most of the functional TWHS are no longer able to cater to the growing demand of the rising population of the locality. In fact, in a large number of cases, the water is no longer used for drinking or cooking purposes due to pollution and contamination.

Although there exist popular writings on TWHS, including those in vernacular languages, hardly any analytical insights could be obtained therefrom[2]. Most of these provide *descriptive* details of the structures, anecdotal information on their history and aspects of management. As TWHS are being seriously reconsidered as possible solutions, partial maybe, to the ever-growing crisis of drinking water, it is important to go beyond *glorifying* the historical roots of these systems. In fact,

---

1 For details of TWHS as found in western India, see, Das (2003: 9-18).

2 For example, Mishra (1993 and 1995).

scientific studies analysing technical feasibility of TWHS, especially in the arid regions of India can be evidenced by, for example, the extensive work carried out at the Central Arid Zone Research Institute (CAZRI), Jodhpur, Rajasthan.[3] Nevertheless, economic *and* environmental analyses of performance of TWHS, used mainly for domestic consumption, are hard to come by. Further, the rise and spread of piped water supply have also necessitated a comparative cost analysis keeping sustainable supply in view. An objective approach to promoting TWHS cannot be over-emphasized.

With this backdrop, the present analysis, which forms part of a larger study concerning western India (Das, 2003), focuses on the potential of revival and modernisation of traditional water harvesting systems and addresses the vital issue of affordability by the rural poor. The empirical content of the study draws upon primary information collected from two villages from Barmer and Jodhpur districts of Rajasthan in the Thar Desert region. Wells have been chosen as the TWHS here as these have continued to prove useful even during summer months in the driest geoclimatic region of India; these are extensively used by the rural communities and are often properly maintained. As suggested by hydrologists and local habitants, these wells had been built with reference to the surrounding nadis (TWHS by themselves) so as to receive water recharged through them. Nevertheless, it is important to explain the choice of wells for the study.

2 Choice of the Harvesting System

There are different types of TWHS in Rajasthan: for example, tankas, talavs, jhalaras, kunds, kuis, wells and khadins. These systems are found according to the topography, soil structure and rainfall pattern. Rajasthan is divided into two distinct hydrogeologic zones, namely, Thar Desert and Central Highlands. The districts falling under the Thar region are Ganganagar, Bikaner, Jaisalmer, Churu, Jhunjhunu, Sikar, Nagaur, Jodhpur, Barmer, Jalore, Pali and Sirohi. The districts of Jodhpur and Barmer were selected for the present study purposes as the TWHS in these two districts have been increasingly used due to recurring droughts in recent years. Whereas in Barmer district the focus was on Kalyanpur tehsil, in Jodhpur district both Mandor and Bhopalgarh tehsils were visited for

---

[3] We owe this information to eminent hydrologist R.N. Athavale. For references to such studies, see, Athavale (2003).

finalizing selection of the villages. These tehsils were reported to have large number of functional TWHS, namely, wells, tankas[4] and nadis[5], although some of them were very old, about 1000 years, some in good working condition and some had been forsaken for the modern systems like piped supply, borewells, handpumps, etc.[6]

According to the available literature (e.g., Agarwal and Narain, 1997), tankas are supposed to be the most prevalent system in both Barmer and Jodhpur. Hence, detailed enquiries were made about these TWHS. However, as it turned out through field visits in the Kalyanpur tehsil, most of the tankas here had been constructed by the local NGOs and these were public access systems built only 4-5 years ago; enquiries were also made about community tankas constructed in the the tehsil. Further, discussion with villagers revealed that the individual tankas in the households were very few due to unaffordability of households to construct these. Only 3-4 tankas were identified in each village.

It may be noted that the two important criteria adopted for this study were that the systems should be locally predominant and accessed by the local population. Eventually, tankas did not meet the aforesaid requirement of the study. Instead, in all the villages, wells (big and small) were the most commonly used system other than the modern systems. But the piped water supply was not effective as the frequency of supply was very low; water flowed only twice or thrice a month. Due to the very low level of groundwater, dependence only on rainwater as the source of drinking water was high. These drinking water sources are nadis,

4 Tankas are systems of roof-top rainwater harvesting. Typically, rainwater falling on the sloping roofs of houses is directed through a pipe into an underground reservoir (tanka) built in the main house or the courtyard. While the first spell of rain is not collected, as this would clean the roof and the pipes, water collected subsequently in the tankas is used only for drinking or cooking.

5 A nadi is a long embankment raised against the ground slopes to arrest surface run-off.

6 Moreover, consultations were held with experts at both the geography department of Jodhpur University and the Central Arid Zone Research Institute (CAZRI) in Jodhpur to confirm the wisdom in the choice of the study districts. Non government organizations (NGOs) such as Unnati at Ahmedabad and Jodhpur, Vasundhara Sewa Samiti at Kalyanpur at Barmer and Dalit Vikas Samiti, Manaklav in Jodhpur were also contacted to discuss the prevailing situation of water supply systems in these districts.

tankas and wells.

In Barmer district, Nagana village of the Kalyanpur tehsil was selected for the purpose of household survey, as the system is very old, still under use and supplies water to whole of the village. A huge well, about 800-900 years old, is the only source of water supply in this village. Water from this well is exclusively used for drinking purposes as villagers realise that it would be inadequate for irrigation. In the past, camels and bullocks used to draw water through the pulley, but now electric motors have replaced them.

The village selected for the household survey in Jodhpur district was Godavas in Bhopalgarh tehsil, where a 600-year old well is still being used. Drinking water in this village is available mainly from the well and the pipeline. The piped water supply, however, is not regular. A tank constructed near the well is connected to the standposts. Whenever piped water is not available, water is pumped from the well and is supplied to the standposts. There are a few other wells in the village but the water is saline, hence unusable.

3 Approaches to the Study

In order to comprehend the status and functional aspects of the system hydrogeological and engineering surveys were carried out. An assessment of the nature of possible improvisation through minimal structural interventions along with the cost that would be involved was also carried out by consulting scientific professionals. In this exercise, the technical experts held detailed consultations with the locally informed people, the locally active NGOs and engineers and hydrologists in the government departments. The capital as well as operation and maintenance (O and M) costs were estimated for reviving/ modernising the TWHS and laying pipe lines to provide household level tap connections in the selected villages. Detailed household surveys focusing on socio-economic and water related aspects were conducted. This was further supplemented by focus group discussions mainly concentrating upon the important issue of community management.

An additional component of eliciting information related to popular willingness to pay for such facilities. The approach followed for this purpose was a slightly modified contingent valuation method (CVM), probably one of the most controversial yet extensively used approaches in environmental economics literature. This method "involves the use of sample surveys (questionnaires) to elicit the willingness of respondents to pay for (generally) hypothetical projects or programs. The nature of the method refers to the fact that the values revealed by respondents are contingent upon the constructed or simulated market presented in the survey" (Portney, 1994: 3). There, however, is no standard set of procedures that may be used to design a contingent value survey. As observed by Hanemann (1994: 21), "While there is no panacea, various procedures have been developed in recent years that enhance the credibility of a survey and make it more likely to procure reliable results." These address a variety of dimensions including sampling, instrument development, formulating of the valuation scenario, questionnaire structure, and data analysis.

In the absence of any substantial study dealing with WTP for TWHS in the Indian context, it was important to devise a set of steps, which could be effectively used in the survey process. Acknowledging the various limitations of the willingness to pay exercises (discussed at length in Reddy, 1999 and Venkatachalam, 2003), a modified CVM, by introducing flexible mode of payment options, was used to obtain an impression about the nature of villagers contribution for different water supply provisions. During the Phase I household survey, the respondents were explained about the potential of TWHS in enhancing the supply of water in the village. Although no 'bid' amount reflecting the household level contribution to the capital costs, in the event the structure was revived was suggested, nor even the exact nature of technological interventions that could be attempted was detailed, the respondents were asked a few questions indicative of their interest in the revival of the systems.

In Phase II of the survey, however, detailed field visits and geohydrological and engineering enquiries were undertaken to ascertain the most appropriate and cost-effective means to revive/ modernise the existing TWHS. Appropriate estimates of capital cost and maintenance expenditure were calculated using scientific parameters. Once such estimates were available, per household share was worked out from the same. It is this amount that was used for the household survey to elicit a realistic idea about the amount that a particular household was willing to pay for the proposed revival/ modernisation of the TWHS and the piped system. Needless to add that prior to canvassing the willingness to pay (WTP) questionnaire to the respondents, an intensive effort was made to explicate and make the respondent familiar with the household level cost of collection of water as construed in terms of time spent and distance covered in fetching water, health costs as a result of water related illness and costs due to irregular supply and scarcity. The nature of interventions specific to the revival of TWHS and laying of pipelines, including identification of a groundwater source, were also explained to the respondents. The direct and indirect benefits gained therewith from each type of intervention in the short and long run were indicated with details, including saving of time and costs involved and the likely benefits from the same. Following this stage, the respondent was asked if he/ she was aware that such an intervention could actually help to increase the availability of water in the village. Information regarding the perception of quality of water drawn from the concerned TWHS and modern piped water supply, wherever available, was also collected to assess the awareness of the respondent regarding the benefits of having not only adequate and regular supply of water but also of improved quality through the suggested interventions.

4 Aspects of Hydrogeology and Water Quality in Sample Villages

Low annual rainfall in both the districts is evident from Table 1. Eventually, low groundwater tables are also a common feature in these areas.

So far as the rock types are concerned, in Barmer district, the presence of calcrete, silcrete, gypseferous bed and claystones represent typical desert near-surface geology; scattered outcrops of granite and rhyolite are also found at different places. The prevalent rock types of Barmer district do not make potential groundwater aquifers. The desert underground strata are poor in groundwater storage and transmission. Deep groundwater of the district is saline. The sample village, Nagana in the Pachpadra tehsil, has high incidence of scattered reddish brown rhyolite hills. The soil type of the village is sandy silt, followed by a clayish composition.

Interestingly, the well in Nagana, reported by villagers to be about 800-900-year old, remains the only source of water for the village. The village and its surrounding area has undulating topography making pathways for drainage courses forming from hill ranges. One large stream traverses near the village.

Table 1: Rainfall and Groundwater Levels at Centres Close to Sample Villages

Year	Nagana (Barmer)				Godavas (Jodhpur)			
	Rainfall (mm) Pach-padra	Water Level (m) in Kalyanpur			Rainfall (mm) Bhopal-garh	Water Level (m) in Kumbharia		
		May	November	Rise		May	November	Rise
1991	144	23.97	NA	NA	318	28.63	NA	NA
1992	430	24.12	23.40	0.72	518	31.25	29.97	1.28
1993	231	23.66	23.42	0.24	268	26.31	30.19	- 3.88
1994	430	23.60	21.60	2.00	608	34.62	32.62	2.00
1995	401	23.52	23.50	0.02	577	34.00	33.40	0.60
1996	216	NA	23.48	NA	683	35.25	33.95	1.30
1997	384	23.50	23.48	0.02	602	33.40	28.96	4.44
1998	341	23.43	NA	NA	367	32.90	NA	NA
1999	283	23.43	23.25	0.18	309	23.43	23.25	0.18
2000	224	23.40	NA	NA	252	23.40	NA	NA

NA: Not available

Source*:* Central Groundwater Board Records, 2001

The exposures of rhyolite hills with a stream emanating from these hills create favorable situation for groundwater recharge. Rhyolite exposures have closely-spaced joints and fractures, which act as channel way for groundwater movement. Such fracturing of rock is not uniform throughout, but confined to certain patches only. Groundwater movement through such fractures receives rainfall recharge through drainage and such locations are favourable site for open wells. On such a favourable site is located the sample open well.[7] Table 2 provides structural information of the well. It is lined throughout with pink coloured rhyolite slabs and an automatic submersible pump of 15 HP has been lowered in the well. Water drawn from the well is being used for water supply to the entire village. Importantly, as per the hydrologists, the Sevalia nadi, situated in the north of village, recharges the well. The recharge process takes place through the close spaced joints and fractures in the rhyollite exposures. This nadi is 120m long and 8m wide. The catchment area is about 400 hectares. There are two more nadis in the vicinity and, if revived, could contribute to the recharging of the well.[8]

---

[7] In order to pump water from the well, a pump has been installed and a ground level reservoir (GLR) constructed under the Rajiv Gandhi National Drinking Water Mission (RGNDWM).

[8] First, of the 120m long Undaria nadi the outflow (spillway) section is damaged and the

Table 2: Structural Dimensions of the Selected Wells in Sample Villages

Details	Nagana	Godavas
Diameter	3 m	3 m
Depth	30 m	27.55 m
Water level	26.20 m	25.20 m
Submersible pump (at 28m depth)	15 hp	Not applicable
Oil engine installed on well top*	Not applicable	8 hp
Pumping hours	6 hours	45 minutes
Discharge rate	4 lps	3 lps
Volume of water /day	86400 litres	8100 litres**

Notes: * With a centrifugal pump fitted at the depth of 24m.
** As per information gathered from villagers, following the rains i.e., upto the month of October the open well can be pumped for 5 hours a day; during this period a volume of 54000 lpd is available against the requirement of 92000 lpd.

Source: Field Survey, 2002

The second village, Godavas in the Bhopalgarh tehsil of Jodhpur district, has a gently sloping flat land typical of the Thar Desert landscape. Absence of any major river along with salinity of groundwater makes conditions difficult on water supply front. At a few places villagers have drilled tubewells to a depth of 80m to 100m. However, due to lowering of water levels and occurrence of hard rhyolite after 100m depth, the discharge in tubewells have decreased. Although a pipeline supplements to this supply, its unreliability has been a problem. The soil type of Godavas village is typical of the desert terrain. Calcrete, claystone, fine sandstones and hard rocks of rhyolites are found at the depth of 90-100 m.

In this village too a 600-year old well (as reported by villagers) continues to cater to domestic needs; its structural parameters have been provided in Table 2. The two nadis close to the well site could, with intervention, help recharge the well. In the Godavas nadi (the embankment wall of which is 1200m long and 8m wide) rainwater is stored in three different pits. In the year 2001 one pit of 50m x 50m was dug to 1.5m depth, but the digging is incomplete. Recharge through the structure may benefit the well, which is situated across the road. If three pits of

---

talav does not store water at present. The nadi can store 3000m^3 of water. Revival of the nadi will help recharge wells down stream. Second, the Pilundia nadi, 300m long and 6 m wide with a large catchment of 500 hectare, currently has its embankments broken. When revived this nadi will store about 20,000 m^3 of water.

2500m^2 area are dug to a depth of 1.5m, the nadi will store 11000m^3 of water when full. The overflow spillway structure is 30m long and 4m wide and in need of repair. Similarly, the Indokia Nadi, in the east of the village, is about 30m long and silted up. Desilting alone would help recharge the well.

The quality of water from the wells in both the sample villages was ascertained through both chemical and bacteriological analyses of water samples. Whereas chemical test results (Table 3) indicated that water was of potable quality, the bacteriological test results revealed that the water was contaminated with the presence of coliform bacteria in high concentrations (Table 4). As per scientific recommendations, mere treating the water with such simple and inexpensive materials like bleaching powder or chlorine would render the water potable; that largely clears a widely held view that water from TWHS is necessarily not safe, hence, not potable. Whether, some sources are to be abandoned, primarily due to lack of any scope to improve water quality, even up to the level of being used for domestic purposes (other than human drinking) only, should be left exclusively to the discretion of the scientific experts.

Table 3: Chemical Analysis of Water Samples from Wells in Two Villages

Village	Nagana	Godavas
Depth	30 m	27.55 m
SWL	26.20 m	25.20m
EC mmhos/cm	2100	1800
PH	7.7	7.8
TDS ppm	1350	1310
Calcium (Ca)	65/3.75	55/2.75
Magnesium (Mg)	52/3.70	42/3.50
Sodium (Na)	170/10.74	270/11.74
Carbonate (CO_3)	Nil	Nil
Bicarbonate (HCO_3)	534/9.40	634/10.40
Sulphate (SO_4)	110/2.80	144/3.00
Chloride (Cl)	80/3.51	160/4.51
Remarks	*Suitable for use*	*Suitable for use*

Note: Chemical Test for pH range, TDS, Ca, Mg, Na, CO_3, HCO_3, SO_4, Cl; with reference to standard upper limits were conducted.

Source: Based on technical analysis of report on chemical examination of water samples conducted at the Public Health Engineering Department Laboratory, Jodhpur, Rajasthan, dated June 29, 2002.

Table 4: Bacteriological Test Results of the Water Samples of Wells in Two Villages

Village	**Bacteria**	**Standards of Purified Water**	**Test Results (mg/l) (Except pH)**	*Remarks*
Nagana	Coliform Organism	10 mpn/ 100 ml	1100 mpn/ 100 ml	Extremely contaminated, needs bleaching powder or chlorination treatment
Godavas	Coliform Organism	10 mpn/ 100 ml	240 mpn/ 100 ml	Highly contaminated, needs bleaching powder or chlorination treatment

Source: Based on technical analysis of report on bacteriological examination of water samples conducted at the Public Health Engineering Department Laboratory, Jodhpur, Rajasthan, dated June 29, 2002.

5 Socio-economic Characteristics of Sample Villages

Being remotely located both the villages surveyed are poorly endowed with basic infrastructural facilities. The main livelihood source, as per Census 1991 statistics, remains agricultural activities (Table 5). Whereas Nagana in Barmer is predominantly a tribal village with 61 per cent of the households belonging to the Scheduled Tribe category, a high proportion (88 per cent) of the households in Godavas belong to Scheduled Castes and Other Backward Castes (Table 6). In both the villages the average landholding size is very low (just about 0.8 hectares), dominated by marginal farmers (Table 7). Further, with scanty occupational opportunities available in the locality, the household income levels suggest high levels of poverty (Table 8).

Table 5: Distribution of Workers in the Sample Villages, Rajasthan

Particulars	Nagana		Godavas	
	Males	Females	Males	Females
Main Workers	175	12	138	15
Cultivators	100	7	111	13
Agricultural Labourers	15	3	4	-
Livestock & Allied Activities	20	1	-	-
Mining & Quarrying	20	-	-	-
Household Industry	3	-	14	-
Trade and Commerce	10	1	2	2
Transport Storage and Communication	-	-	2	-
Other Services	7	-	5	-
Marginal Workers	10	100	15	159
Non workers	155	179	178	135

Source: *District Census Handbook, Barmer and Jodhpur, 1991*

Table 6: Caste and Family Size of Sample Households

Particulars	Nagana	Godavas
Number of households	41	43
Population	209	267
Average Family Size	5.1	6.2
Scheduled Castes	3 (7.3)	11 (25.6)
Scheduled Tribes	25 (61.0)	1 (2.3)
Other Backward Castes	9 (22.0)	27 (62.8)
General	4 (9.8)	4 (9.3)

Note: Figures in parentheses are proportions to the total number of sample households in the village.

Source: Field Survey, 2001

Table 7: Landholding Status of the Sample Households

Landholding	Villages (No. of Households)	
	Nagana	Godavas
Average Landholding (in Hectares)	0.83	0.80
<1 ha (Marginal)	25	22
1-2 ha (Small)	3	10
2-10 ha (Medium)	6	1
Landless	7	10
All	41	43

Note: The figures in parentheses are the proportion to the total number of sample households in the village.

Source: Field Survey, 2001

Table 8: Income Classes of Sample Households

Village	Income group (Monthly income in Rs.)			
	< 1000	1000-4000	> 4000	All
Nagana	22 (53.7)	18 (43.9)	1 (2.4)	41 (100.0)
Godavas	12 (27.9)	31 (72.1)	-	43 (100.0)

Note: Figures in parentheses are percentages to respective row totals.

Source: Field Survey, 2001

6 Pattern and Sources of Domestic Water Consumption

Table 9 indicates that about two-fifths of the total water requirement of the households in both the villages is not being met by the existing sources. The major dependence of households on selected TWHS in the sample villages for water for domestic purposes and livestock can be gauged from the purpose-wise proportions. Further, as shown in Table 10, the overwhelming dependence on traditional sources in both the villages (cent per cent in Nagana and 57 per cent in Godavas) underscores the significance of TWHS as important sources. The use of water from TWHS, however, was based on varied perception about its quality. An idea about the perceived quality dimension can be had from Table 11. As may be observed, at least 70 per cent of the sample households considered the water was good and potable.

7 Cost of Improved Water Infrastructure and Willingness to Pay

Estimates of cost of revival/ modernization of TWHS and laying of piped water system in the two villages surveyed are presented in Tables 12 and 13, respectively. As mentioned before, the wells could be recharged through the surrounding *nadis*, which essentially form the potential catchment area. Hence, the augmentation of wells would have a strong component of developing and desilting the nadis; the costs reflect the same. It is important to note that, even though the initial capital costs for developing the TWHS are clearly higher compared to that for the piped system, the reliability of the former is much greater in a region where groundwater availability is a serious constraint. Unless an assured alternative external water source is identified/ created for the piped scheme, digging borewells in the arid belt shall be both unsustainable and disastrous.

An idea about the responses across size classes of income can be had from Table 14. Excepting a couple of households, the very small number of villagers who are willing to pay would agree for a maximum of half the cost suggested. Further, as revealed in Table 15, in both the villages, a strikingly negligible number of households expressed their willingness to contribute towards capital cost of either of the proposed systems. Moreover, those who agreed to pay, the amount indicated by them was a paltry about 2 per cent of their monthly household income. This response could be attributed not only to the high incidence of poverty but also to the fact that these villages still manage to meet much of their water requirement from the village wells even during the difficult summer months. Nevertheless, an overwhelmingly favourable response was obtained so far as contributing for O and M was concerned and also if the contribution would be labour. The abject poverty of the households and absence of development of the local region obviously would, eventually, deter popular participation involving cash payment, even when easy modes of payment are introduced. This may be applicable elsewhere in rural India as well. Even when data on WTP are classified across income and landholding size, these have limited scope of explanation, as the total number of those willing to pay was extremely small.

Table 9: Demand Pattern for Domestic Water Use in Sample Villages

(litres per day)

Purpose	Nagana		Godavas	
	Total Quantity Used	Per Capita Qty Used	Total Quantity Used	Per Capita Qty Used
Drinking (Human)	1765 *{100.0}*	8.4	2087 *{77.1}*	7.8
Cooking	848 *{97.7}*	4.1	902 *{67.6}*	3.4
Bathing (Males)	983 *{100.0}*	13.7	1210 *{58.4}*	14.2
Bathing (Females)	828 *{100.0}*	15.6	1227 *{59.3}*	16.1
Bathing (Children)	830 *{100.0}*	9.9	1197 *{73.5}*	11.3
Washing Clothes	2180 *{100.0}*	10.4	2815 *{57.0}*	10.5
Washing Utensils	1065 *{100.0}*	5.1	1188 *{63.1}*	4.5
Latrine	144 *{100.0}*	0.7	853 *{10.5}*	3.2
Drinking (Livestock)	230 *{100.0}*	2.6*	526 *{10.5}*	4.9*
Washing (Livestock)	195 *{100.0}*	6.3	252 *{-}*	3.6
All Purposes	9068 *{100.0}*	30.6	12257 *{57.4}*	32.8
Standard Quantity (Human)	12000		15880	
Standard Quantity (Livestock)	2610		3220	
Deficiency (Human)	3357 (28.0)		4401 (27.7)	
Deficiency (Livestock)	2380 (91.2)		2694 (83.7)	
Total Deficiency	5932 (39.3)		7347 (37.2)	

Notes: Standard quantity for human consumption is based on the criterion of 40 lpcd (litres per capita per day)

Standard quantity for livestock (cattle at 30 lpcd and, sheep and goat at 10 lpcd)

Total deficiency includes deficiency for human and livestock consumption plus the actual quantity of water used for animal washing.

Figures in *{ }* show percentage of water used from the selected TWHS (well)

Figures in ( ) are the percentage of deficiency towards standard quantity required.

* The notable variation between these two figures could reflect *type* of livestock as found in the sample households, in the two villages.

Source: Field Survey, 2001

Table 10: Demand for Water Met by Traditional and Modern Sources

(Percentages)

Village	Source			
	Traditional	Selected TWHS (Well)	Modern	All
Nagana	100.0	99.8	-	100.0
Godavas	58.8	57.4	41.2	100.0

Notes: Source in Nagana: traditional - talav.

Sources in Godavas: traditional – talav, modern – stand post.

Source: Field Survey, 2001

Table 11: Respondents' Perception on Quality of Water of Wells in the Sample Villages

(No. of Households)

Perception About Quality	Nagana	Godavas
Potable (Good for drinking, cooking and domestic use)	35 (100.0)	30 (69.8)
Non-potable but used for other domestic purposes	-	13 (30.2)
Used for domestic purposes but not for cooking and drinking	-	12 (27.9)
Used only for livestock drinking	-	1 (2.3)

Source: Field Survey, 2001

Note: Figures in parentheses indicate the proportion of sample households

Table 12: Cost Estimates for Revival of TWHS

Particulars	Amount (Rs.)
Nagana	
Cost of desilting nadi 10,00,000 cubic feet (Desilting material can be used in strengthening the bank of nadi and includes the improvement of nadi catchment/ channel)	5,66,000
Making approaches and livestock drinking stands	34,000
Total	6,00,000
Godavas	
Cost of desilting nadi Phase I (25,00,000 cubic feet = 70750 cubic metre @ Rs 17.67/ cubic metre)	12,50,000
Cost of desilting nadi Phase II (desilted earth will be used for strengthening nadi banks and improvement of nadi channel)	10,00,000
Total	22,50,000

Source: As prepared by hydrologists and concerned civil engineers.

Table 13: Cost Estimates of Laying Piped System

Particulars	Amount (Rs.)
Nagana	
Laying of pipelines –50mm diameter	1,86,000
Distribution lines for 103 houses and Panchayat Ghar school and dispensary	90,000
Installation of infrastructure for pumping and storage	40,000
Total	3,16,000
Godavas	
Laying of pipelines – 50 mm diameter	1,50,000
Installation of infrastructure for storage and boosting of water	2,00,000
New tubewell with pump	1,70,000
Total	5,20,000

Source: Same as in Table 12.

Table 14: Willingness to Pay for TWHS and Piped System Across Income Classes

Income (Rs. Per Month)	System	Proportion of Amount of WTP					
		0	< 25%	26-50%	51-75%	100%	All
Nagana							
< 1000	T	15 (42.9)	3 (8.6)			1 (2.9)	19 (54.4)
	P	17 (48.6)		1 (2.9)		1 (2.9)	19 (54.4)
1000-4000	T	12 (34.3)	2 (5.7)	1 (2.9)		1 (2.9)	16 (45.8)
	P	13 (37.1)	1 (2.9)	1 (2.9)		1 (2.9)	16 (45.8)
All classes	T	27 (77.1)	5 (14.3)	1 (2.9)		2 (5.7)	35 (100.0)
	P	30 (85.7)	1 (2.9)	1 (2.9)	1 (2.9)	2 (5.7)	35 (100.0)
Godavas							
< 1000	T	9 (20.9)	3 (7.0)				12 (27.9)
	P	11 (25.6)	1 (2.3)				12 (27.9)
1000-4000	T	27 (62.8)	2 (4.7)	2 (4.7)			31 (72.2)
	P	30 (69.8)	1 (2.3)				31 (72.1)
All Classes	T	36 (83.7)	5 (11.6)	2 (4.7)			43 (100.0)
	P	41 (95.3)	2 (4.7)				43 (100.0)

Notes: T: TWHS (Well) P: Piped system
Figures in parentheses are percentages to the total number of sample households in the respective villages.

Table 15: Households' Willingness to Pay for Revival of TWHS and Laying of Piped System

Village	TWHS			Piped System		Total Sample Households
	Capital Cost	O & M	Labour	Capital Cost	O & M	
Nagana	5 (14.3)	34 (97.1)	34 (97.1)	2 (5.7)	6 (17.1)	41
Godavas	2 (4.7)	43 (100.0)	43 (100.0)	-	-	43

Note: Figures in parentheses are the proportions to the total number of sample households

8 Issues in Reviving and Managing the TWHS

Issues of management and maintenance of TWHS were enquired into with the help of village level focus group discussions (FGDs) and household surveys. In case of the well in Nagana, originally, it had been constructed by the local royal family who took care of the structure. Later, a temple was built by them in the vicinity of the well and caretakers of the temple have long been exclusively maintaining this well, protecting it from being used for purposes other than drinking and cooking. The structure – the well, its platform and the trough – has been kept clean/ functional and repairs undertaken whenever needed. No specific local water committee exists for managing the source, nor any charges are levied by the temple administration for its use by villagers. The panchayat is also supportive of the upkeep by the temple functionaries of the system, which remains practically the only source of potable water for the entire village. This is a village where the use of well has been extensive and, expectedly, care had been taken to keep the water clean.

However, this was not so in case of Godavas village, where the neglect meted to the structure was apparent, as local community did not involve itself in its upkeep. As an alternative source of water was available in the village, through government laid pipelines leading to a cistern fitted with standposts, the well was in use as and when the piped supply failed or was inadequate due to electricity problems or breakdowns. Fuel and repair needed for the oil engine fitted to the well have been the responsibility of the panchayat and occasionally through local contributions. Rather, the villagers expected complete or partial involvement of state government in managing and maintaining the sources as there prevailed a general lack of confidence in the efficacy of the sarpanch in managing the source. In both the cases, nevertheless, women had not have a role to play in managing the source. So far as the structure *per se* is concerned, in both the instances depleting groundwater levels and rise in salinity necessitated desilting of the nadis and local talavs.

It is important to appreciate that the high costs of desilting are one time costs arising out of neglect of maintenance of these centuries old structures during the preceding few decades. As recorded in Mishra (1993 and 1995), there used to be the tradition of annual desilting through *shramdan* (free contribution of labour), a collective action that sustained the structures through a sense of participation and responsibility. The fading away of such practices (and institutions), where community's role in maintaining key CRPs was remarkable, has been a cause of concern as it has resulted in widespread neglect of the sources. Strategies, including incentives, need to be planned so as to reintroduce these community initiatives, especially, if once the capital expenditure on major desilting is undertaken by government agencies. The important point made is that desilting of local surface water sources, although more expensive, is preferable over piped water supply from elsewhere. The latter is not sustainable both because of natural resource constraint and of the poor maintenance of structures involved in the supply.

9 Concluding Observations

This paper makes a detailed study of domestic water availability in two villages in the low rainfall regions of Rajasthan. It was apparent that TWHS were not or will not be able to cater to the *total* requirement of drinking water in the villages, mainly due to the rise in population in the past decades. Nevertheless, if revived/ repaired and, importantly, managed by the village level institutions (panchayat, to be specific), these sources can be of substantive use, especially, during summer.

A close look into the pattern and extent of local/ household level willingness to finance such revival/ modernisation provides interesting insights into the nature of popular response. First, most households in these Rajasthan villages are living in extreme poverty and, naturally, have refused to pay at all for the water from either TWHS or piped systems. Moreover, the villagers are perfectly aware that the existing wells, from where they have been freely drawing water even during the peak summer months, shall continue to meet their minimum basic demand for potable water. This, in a sense, assumes that such supply could be maintained in future; the emphasis on sustaining and augmenting the source is clear. Second, unlike the capital cost, most villagers were willing to pay for the O and M of TWHS. People's willingness to contribute in terms of labour indicates the preference for the revival/ modernisation of the TWHS. An important aspect of this exercise in assessing WTP is that even the most sophisticated methods of valuation may be inadequate to elicit information on the WTP behaviour if the respondents refuse to participate in the 'bidding' process due mainly to abject poverty and rejecting the very proposal that potable water could be priced for the rural poor. That calls for a different regional development strategy which would contribute to the augmenting of the local income opportunity, possibly through strengthening all forms of rural infrastructure.

Wells in western Rajasthan, the Thar Desert region specifically, have continued to prove useful even during summer months in the driest geo-climatic region of India. An important hydrogeological characteristic of wells is that the structures could have been linked to underground perennial streams/ channels and/or be recharged through the surrounding nadis. Such ingenious selection of location and construction of the structures ensures a steady supply of water in the wells. These wells hold much potential to be revived and modernized.

Growing dependence on the piped water system alone, though preferable and convenient, has implications of increasing cost in future either due to increase in population or depletion of groundwater or both. Additionally, the ubiquitous problem of unreliability of piped water supply has serious implications for considering alternative sources. Hydrogeology specific technological strategies to harness rainwater and modernise TWHS need to be explored as enhanced supply *per se* can reduce costs significantly. In such ventures whether and how state can intervene or shall seek private participation, both for financing and providing technical and management support is an issue to be explored. In TWHS, the trickier issue is management with community participation.

One most effective approach shall be to desilt, deepen and widen the concerned nadis; this could ensure a substantial increase in availability of water in the wells, which may be stored for a long period of time. These structures are also viable options in these regions where piped water system is most likely to fail due to very low level of groundwater tables. It is important to move beyond mere glorifying these systems in an anecdotal manner; these important heritage resources from the past need to be evaluated for their existing and potential contribution, even if partially meeting local domestic water needs; a scientific approach to TWHS promotion cannot be over-emphasised. In the process, there would be important lessons to learn to revive and/ or recreate similar systems elsewhere depending upon their merit and suitability in addressing the drinking water crisis.

References

Agarwal, Anil and Sunita Narain (eds.) (1997), *Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems,* Centre for Science and Environment, New Delhi.

Agarwal, Anil, Sunita Narain and Indira Khurana (2001), *Making Water Everybody's Business: Practice and Policy of Water Harvesting,* Centre for Science and Environment, New Delhi.

Athavale, R.N. (2003), *Water Harvesting and Sustainable Supply in India,* Centre for Environment Education, Ahmedabad and Rawat Publications, Jaipur.

Barah, C. Bhuban (1996), *Traditional Water Harvesting Systems: An Ecological Economic Survey,* New Age International, New Delhi.

Bhagyalakshami, J. (2001), 'Water Harvesting for Drought-Prone Areas', *Yojana,* 45 (1 and 2).

Bishnoi, Aarti (2000), *Impacts of Traditional Water Harvesting Structures,* Dissertation submitted to the Centre for Environmental Planning and Technology, Ahmedabad. (Unpublished).

Das, Keshab (2001), 'Rural Drinking Water Supply in India: Issues and Strategies', in Sebastian Morris (ed.), *India Infrastructure Report 2001: Issues in Regulation and Market Structure,* 3iNetwork, Oxford University Press, New Delhi.

Das, Keshab (2003), 'Reviving a Water Heritage: Economic and Environmental Performance of Traditional Water Harvesting Systems in Western India', *EERC Working Paper Series: WIS-1*, Indira Gandhi Institute of Development Research, Mumbai.

Hanemann, W. Michael (1994), 'Valuing the Environment through Contingent Valuation', *The Journal of Economic Perspectives*, 8 (4).

Mishra, Anupam (1993), *Aaj Bhee Khare Hain Talaab (Ponds: A Living Tradition),* Gandhi Peace Foundation, New Delhi. (In Hindi).

Mishra, Anupam (1995), *Rajasthan ki Rajat Bundein (The Silver Drops of Rajasthan),* Gandhi Peace Foundation, New Delhi. (In Hindi).

Portney, Paul R (1994), 'The Contingent Valuation Debate: Why Economists Should Care', *The Journal of Economic Perspectives*, 8 (4).

Reddy, D. Narasimha, B.C. Barah and T. Sudhakar (1993), 'Decline of Traditional Water Harvesting Systems: Trends in the Drought-prone Areas of Andhra Pradesh', *Indian Journal of Agricultural Economics,* 48 (1).

Reddy, V. Ratna (1999), 'Pricing of Rural Drinking Water: A Study of Willingness and Ability to Pay in Western India', *Journal of Social and Economic Development,* 2 (1).

Sridhar, Alpa (2001), *Study, Documentation and Assessment of the Feasibility of Revival of Traditional Drinking Water Harvesting Systems and Practices Prevalent in the State of Gujarat,* Draft Report submitted to Pravah, Ahmedabad (Mimeo, unpublished).

Vaidyanathan, A. (ed.) (2001), *Tanks of South India,* Centre for Science and Environment, New Delhi.

Venkatachalam, L. (2003), 'Designing Contingent Valuation (CV) Surveys for Estimating Use Values: Some Experience from a Case Study of a Water Supply Project', *Journal of Social and Economic Development,* 6 (2).