

Rethinking Rehabilitation:
Socio-ecology of Tanks in Rajasthan, North-West India

Tushaar Shah

Research Leader, International Water Management Institute, Colombo

K Vengama Raju

Senior Fellow, Institute of Social and Economic Change, Bangalore

Abstract

In the arid and semi-arid state of Rajasthan in North West India, tanks and ponds have been the mainstay of rural communities for ages. Particularly in the eastern parts of the state, besides numerous *johad's*, *bandh's* and *pal's* (tank like small water harvesting structures), there are some 4600 large minor irrigation (MI) tanks, many of which were built by the *Rajah's* and *Jagirdaars* in the 19th century or even earlier. These were traditionally managed for multiple uses by local communities through an intricate web of customs, traditions, and community sanctions which got eroded with the decline of the *Zamindari* system. During the 1950's, MI tanks were brought under the management of the State Irrigation Department which, being perpetually strapped for resources, has been able to invest little in their maintenance and repair.

Even in their decrepit state, Rajasthan's tanks are a socio-ecological and economic marvel, performing many useful functions, almost without cost to the public exchequer. This paper assesses a strategy currently proposed for rehabilitating some 1200 of the larger tanks. The central argument it develops is that the view of tanks as pure flow irrigation systems—which lies at the center of the mainstream thinking on rehabilitating surface irrigation systems -- is very likely to result in a flawed strategy when applied to tanks. Instead, reviewing the successful experience of NGOs like PRADAN and Tarun Bharat Sangh in reviving and rehabilitating clusters of small traditional water harvesting structures at a watershed level, we posit that Rajasthan's tanks belong more to the watershed development domain than to the irrigation domain and that a strategy that views tanks as multi-use socio-ecological constructs, and which recognizes and builds upon the intricate layering of rights and obligations by varied stake-holder groups is more likely to enhance the social value of tanks.

1. Background

As the potential for creating new irrigation capacity approaches closure, many developing countries and international donor agencies are turning to ways of enhancing the productivity and performance of existing irrigation infrastructure through rehabilitation. In the face of growing water scarcity, there is also new-found interest in applying the notion of rehabilitation to small traditional water harvesting and irrigation systems which have existed for many decades or even centuries in countries like India. In the strict sense, 'rehabilitation' has traditionally meant technical interventions aimed at restoring a system to its original design potential for performance (FAO 1997)¹. However, critical assumptions made in the original design are often erroneous; and in any case, over a long period after the commissioning of a new system, the conditions in the domain of an irrigation system too change a good deal and warrant a different design appropriate to modern conditions. As a result, a broader conception of rehabilitation often questions the original design and results in its modification to suit contemporary domain conditions. More recently, there is also growing recognition of the importance of effective institutional change as a precondition to the success of a rehabilitation program; and in the debate on farmer participation in irrigation management, an issue of interest now is whether institutional intervention preceding technical rehabilitation—rather than vice versa-- might not enhance the overall chances for improved performance. The original narrow notion of rehabilitation continues to have a powerful sway over irrigation establishments as well as donor agencies. As a consequence, a good deal of what goes on under 'rehabilitation' continues to be 'technical intervention aimed to restore the system to its original design potential for performance'.

¹ According to Renault (1998: 5) Rehabilitation.. 'consists of reengineering a deficient infrastructure to return it to the original design.' But modernisation implies 'fundamental changes in the rules governing water resources management. Modernization may include interventions to the physical infrastructure as well as to its management.' According to an FAO conference (cited in Kalu 1998:169), 'Modernization is a process of upgrading (as opposed to mere rehabilitation) of irrigation schemes combined with institutional reforms, if required with the objective to improve resource utilisation (labour, water, economic, environment) and water delivery service to farms.'

This conventional, narrow notion of rehabilitation is at the heart of a strategy proposed in the arid and semi-arid state of Rajasthan in north-western India for improving the performance of large irrigation tanks (GoR 1997a & b). It is also at the heart of a new strategy being evolved by the Government of India on a country-wide approach to tank rehabilitation (Planning Commission 1999). In assessing this strategy, this paper adduces evidence and insights gained in the course of field research on tank communities of Eastern Rajasthan carried out during 1998, and suggests that [a] while conventional notion of rehabilitation is destined to fail when applied to Rajasthan's tanks, even the broader, modern notions of rehabilitation would need considerable refinement before they will address issues central to improving their overall performance; [b] a major challenge is in evolving a conception of tank performance appropriate in the context of Rajasthan's tanks; [c] tank rehabilitation needs to be planned in the river basin context especially in basins that are approaching closure²; and [d] a strategy that has greater chance of success is likely to be one that views tanks as complex socio-ecological systems with multiple stake-holder groups rather than the present one which treats them as pure flow irrigation systems.

The research reported here was carried out as part of an assignment to review the proposal developed by the Government of Rajasthan for rehabilitation of some 1200 of the largest MI tanks for the Swedish International Development Agency. The sections on the work done by NGOs like PRADAN and Tarun Bharat Sangh also drew heavily on Tushaar Shah's work for the Swiss Development Agency on the evaluation of PAWDI (Participatory Watershed Development Initiative) project implemented by Government of Rajasthan and a group of Rajasthan NGOs. The approach used in both these focused heavily on participatory appraisal techniques, focus group discussions and unstructured interviews with opinion leaders. The field research covered interviews with tank community members in some 25 tanks in five districts-*viz.*, Bhilwara, Ajmer, Jaipur, Alwar, Bundi and Tonk. Tanks covered encompassed all variety, large and small, those managed by the department and those managed by *Panchayats* (Village Councils); those where revenue assessment and

² When water diversions in a river basin approach net inflow of water into it so that there is no scope for new water development, the river basin is said to be approaching 'closure'.

collection is done by the irrigation department and those where it is done by the revenue administration. The authors also interacted with prominent NGOs—notably, PRADAN and Tarun Bharat Sangh (TBS) in Alwar and a TBS associate NGO in Chaksu tehsil of Jaipur district. Besides extensive fieldwork, the authors also scrutinized available documents and relevant literature; and interviewed a broad cross-section of officials from the Irrigation Department, researchers and development practitioners in course of which many of the perceptions and conclusions gathered from fieldwork were triangulated. The effectiveness of this approach proved variable; information available about the current state and productivity of tanks was patchy; moreover, there was little by way of research and analyses of tank systems by independent researchers that we could use to form our judgements. As a result, some of the key arguments of the paper still remain in the nature of hypotheses rather than conclusions; even so, the central argument of the paper—that ‘conventional’ engineering rehabilitation would not improve performance of tanks—remains a robust conclusion.

2. Problem and Proposed Solution

Rajasthan, including the Thar desert, forms one of the most arid regions of India. The state receives an average of around 550 mm of rainfall; and has a per capita water availability of around 700 cu m, way below the all India average of over 1200 cu m (GOR 1996:17). The bulk of this rain is received in the span of a few hours in torrential showers. Small check dams called *johads* or *paal's* with water spread areas of a few acres, and larger minor irrigation (MI) tanks—with command areas of 1000 ha or more-- are the mainstay of the state's rural communities especially in the eastern and southern parts. Rajasthan has 4600 such minor irrigation tanks with an estimated potential command area of 630,000 ha. Typically, these have earthen dams with a *pucca* overflow structure and one or more sluices; from each of the sluices emerges a canal, mostly unlined, but often provided with *pucca* outlets irrigating *chaks* (i.e., command areas) of various sizes. A large number of these tanks (2272 according to GOR 1997a) were built before India attained Independence in 1948; some, built by the *Rajahs* and *Jagirdaars* are over 100 years old; however, some are new and were constructed by the Irrigation Department (ID) of the Government of Rajasthan

(GOR), mostly under famine relief schemes. A major concern of the ID is that all these tanks—old as well as new—have uniformly fallen into disrepair. The tank beds have been silted up, particularly near the dam, reducing their storage capacity far below their potential. Siltation near the sluice gates often blocks the gate partially and/or raises the sill level enlarging the dead storage. Inefficient water distribution systems are problematic, too. Sluice gates in many systems are in a state of disrepair; in many, water keeps leaking out continuously. Poorly maintained cross-drainage works result in wastage of water and damage to structures. Most tanks have only have only *kuchcha* (i.e., unlined earthen) canals; few have portions of main canal/s lined. After years of siltation, the carrying capacity of canals has also been reduced. On many old canals, there are no outlets; so farmers make breaches and divert the flow to their fields; and frequent breaching has made the canal walls weak. On-Farm Development (OFD) work is of poor quality or non-existent. On their own, farmers do some maintenance work; in most systems, before the irrigation season commences, farmers co-operate in small groups to clean the canal in portions closest to their fields of weeds, grass and other foreign matter so that water flows smoothly. However, nowhere did we find them desilting the canals or strengthening the canal walls or deepening the canal beds. The ID is concerned about the consequences of all these. Seepage rates during conveyance are high. Water takes a long time to reach the tail end field; the number of days the system has to operate to complete one round of irrigation has been increasing. In many systems, tail-end farmers face difficulty in receiving water at all, particularly in years of low rain-fall when the tank has filled only partially and the need for irrigation is acute. At such times, the problems of equitable distribution of water between head reaches and tail farmers get aggravated. Commonly, tail-enders hardly manage to get one irrigation when head-reach farmers get three.

The strategy devised by the Government of Rajasthan (GoR 1997 a and b; GOR 1998) to restore the tanks to their design potential entails: [a] major renovation of the physical structures—bund, sluice gates, canals—by the ID in 1198 of the largest tanks; [b] organisation of command area farmers into Water User Associations (WUAs); [c] turn over of the O & M of the distribution system below the minors (but *not* the head-works and the main canals) to the WUAs, along with the responsibility of fixing and collection of

irrigation fees, and evolving and enforcing norms for water distribution; and [d] strengthening and modernizing the Minor Irrigation Division (which is responsible for tanks) and the infrastructure at its command including vehicles, computers, communication system. The most important benefit of implementing the strategy, it is claimed, would be an additional command area of 64000 ha under irrigation partly as a result of expansion in storage as well as improved distribution systems, and partly as the Project closes the gap between the designed intensity of irrigation of 59% and the actual intensity of irrigation estimated at 51%. This would enhance the net annual agricultural production in the command by an estimated value of US \$ 30 m against an investment US\$ 10.3 m of which over 95% is assigned to engineering works including repairs on head-works, canals, farm channels, and other OFD works.

In a recent article (Raju and Shah 2000), the authors have discussed the organisational and ‘process’ aspects of the proposed strategy and suggested an alternative that they think has a better chance to work. In this paper, we analyse some of the basic notions underlying the present strategy of rehabilitation. There are several grounds for concern about the proposed strategy:

- First, it is expensive: the cost/ha of new irrigation potential at nearly US 1600 is high compared with the average cost of US \$ 1280 incurred in constructing new small scale systems during 1992-6 period and several times higher than costs incurred by NGO programs with people’s participation in construction.
- Second, its sequencing of interventions is problematic: it is proposed that Irrigation Management Transfer (IMT) to Water User Associations (WUAs) will begin only after the technical rehabilitation is completed by the Department when experience world-wide suggests that farmers lose interest in taking over the management of systems once rehabilitation is completed especially if it does not involve their participation.
- Third is the half-hearted turn-over strategy: it is proposed that only the distribution system at the minor level and below is to be turned over to farmers’ WUAs while the head-works and the main canal will

still be controlled and managed by the Department; this may unduly limit the role of the WUA's and fail to address the dependency of the farmers on ID.

- Fourth is its flawed conception of the role of tanks: we believe the proposed strategy takes too narrow a view of the role of tanks purely as flow irrigation systems where as in reality, Rajasthan's tanks play a complex set of multiple roles for a diverse group of stakeholders. Entrusting their management to WUAs of command area farmers may exclude important stake-holder groups and ignore several critical roles tanks play in their local socio-ecologies.
- Finally, its failure to consider the bigger picture: many river basins in Eastern Rajasthan are approaching closure, a state in which, *ceteris paribus*, it is not possible for one tank community to benefit without some other community losing. We therefore believe that a rehabilitation strategy that addresses an entire river basin or a macro watershed may produce better results than one which focuses on individual tanks.

The rest of this paper focuses on the last two which, in our view, are central to evolving a strategy that can bring about real improvements in water productivity in Rajasthan's tanks.

3. Decrepit, yet marvelous

3.1 Multiple functions, free of cost

Even in their present decrepit state, Rajasthan's tanks are a socio-ecological and economic marvel. At a low opportunity cost, they perform many useful functions, six of which seem particularly notable. First, they help capture, conserve and store what little rainfall the region receives and in the process reduce soil erosion by cutting the pace and momentum of run-off waters. Second, they provide low-cost flow irrigation. Third, they help recharge groundwater aquifers which provide a stable and reliable source of irrigation and domestic water supply in areas surrounding them. Fourth, they reduce the intensity of flash floods and draughts. In a year of high rainfall, such as the 1996 monsoon which resulted in devastating flash-floods in Alwar, Bharatpur and other districts of north-eastern Rajasthan, tanks significantly reduce the threat and damage of flash floods; in contrast, in years of lower than normal rainfall, tanks and aquifer

storage directly fed by tanks provides some protective irrigation. Fifth, tanks concentrate silt and minerals contained in rain water run-off in tank beds and the command area and make the soil fertile. Sixth, and most important, unlike large reservoirs and tanks in South India which take land in the submergence areas away from other uses, tank-beds in Rajasthan are used both for water-storage as well as for cultivation. As a rule, farmers grow winter –and, sometimes, summer-- crops in tank beds after they are emptied; as a result, tanks are efficient in land-use.

3.2 Tank-bed Cultivation

Use of tank beds for farming, locally known as *petta* cultivation is an integral and distinctive feature of the tanks of Rajasthan, as also of other smaller water harvesting and storage structures such as anicuts, *johads*, *pals*, *bandhs*. Indeed, in smaller water harvesting structures, submergence area is the primary beneficiary. *Petta* cultivation is an extensive practice. The legality of *petta*- cultivation is a confused issue but that seems besides the point in understanding the current reality of tanks. Especially in old tanks, the ownership of the submerged lands itself is ambiguous. Commonly, no records exist about the ownership of these lands. Originally, it must have been the *Jagirdaar*'s land; however, private use rights have been established and defended by farmers over several decades. Over time, these have come to be treated as owners of *petta* lands. The practice has continued in newly built tanks, too.³

Over the years, an interesting practice—fancifully called ‘inundation irrigation’—has come into vogue in many tanks in Eastern Rajasthan which involves emptying the entire tank in one go. In the Ramnagar tank on the Boondi-Bijolia road, for instance, the tank storage is emptied in just one long spell of irrigation on 15th September. While the exact dates may differ, in many tanks in Rajasthan, inundation irrigation is formally accepted as an operating practice with consent of farmers as well as the Irrigation Department.

³ In newer tanks, such as Govind Sagar in Ajmer, the Irrigation Department acquired the private fields falling in the submergence area (and the cost of this acquisition, even at government rates, was nearly half of the total project cost in Govind Sagar). The practice in such cases is to give erstwhile owners the right to cultivate for three years after acquisition; thereafter, the cultivation rights on acquired submergence land are either auctioned or departmentally allocated, usually to the original land owners. Moreover, since acquisition is *not* compulsory, many farmers with land in submergence areas refuse to sell their land to the government and retain their ownership rights.

This surfeit of involuntary irrigation creates a 1.5-2' thick sheet of water that covers a large area downstream of the bund including all the fields in the design command and beyond. Fields deprived by gravity flow are sometimes fed by their owners using diesel pumps installed on canal during this inundation irrigation period. Both, the lifters as well as the gravity-flow irrigators—wet their land to the limit, since the next irrigation is not guaranteed, except with a substantial late shower that fills up the tank again. Inundation irrigation serves to help recharge the aquifers; it also helps top soils retain enough moisture to see the rabi crop through. Over the years, the practice of inundation irrigation has produced important changes in districts like Alwar which has a total of 115 tanks⁴, most following variants of this practice. Farmers in the *petta* lands and command areas have, through some process of negotiation, learnt to arrive at a date on which the sluice gates will be opened up for inundation irrigation. The date is critical: it must leave *petta* land farmers enough time to soak their lands; and it must leave enough time for the downstream farmers to dry their lands and get ready for rabi cropping. Inundation irrigation has also affected the upkeep of the infrastructure; since under this practice, canals are not used, these structures have fallen into disuse and disrepair. By default, then, many of the Alwar and Bharatpur tanks have begun to function like out-sized *paals* (bunds). Both in *petta* as well as command areas, a crop of *raido* (mustard) gets taken just using soil moisture with little supplementary well-irrigation. The Irrigation Department is concerned about the state of disrepair of the tank and canal structures. But in some ways, farmer improvisations have resulted in what might be considered the best of a bad situation. In any case, with the profusion of new water harvesting structures in the catchment areas, most tanks in a district like Alwar do not impound enough water to provide intensive irrigation even to their small official design commands. Under the practice of inundation irrigation, it can be argued that the total area the tanks benefit is probably larger than the command they can hope to serve even after rehabilitation.

⁴ including the famous Jai Samand, a big tank with over 900 mcft capacity designed to provide 4 waterings to a command of 3500 ha

In normal gravity flow systems and South Indian tanks, the primacy of command area farmers as the sole or main stake-holder group is unambiguous. In contrast, stake holder groups in the tanks of Rajasthan have far too many conflicting interests for a straight-forward engineering rehabilitation to enthuse all of them (Fig.1). As a result, the central problem in improving farmer management of tanks in Rajasthan is the difficulty in harmonizing the interests of different stake-holder groups. Take the problem of tank bed siltation. The Department considers this the central problem in need of fixing through rehabilitation. But tank-bed farmers have a strong interest in siltation which they find beneficial; it makes the soil fertile; it reduces the period over which their land near the headworks remains submerged but expands the overall area of submergence for just long enough for it to be readied for cropping. In some tanks, siltation gives tank-bed farmers near the bund time to take a rabi as well as a summer crop using soil moisture and groundwater irrigation. There are also similar conflicts of perceptions with respect to the solution to the siltation problem. The technical solution preferred by the Department is de-siltation; however, this involves questions of both economic viability and practicality. A simpler and cheaper answer is to raise the height of the bund by a foot or two to raise storage capacity by several million cubic feet. Although this is highly cost effective, the Department's technical appraisal goes against it because it increases the submergence area—which the department considers a cost--and will also mean higher evaporation losses. Command area farmers agree with the department; but tank-bed farmers prefer raising the bund height to desilting because it expands the submergence area—to their benefit--without unduly lengthening the period for which the tank-bed *petta* land near the bund remains submerged. In tanks practicing 'inundation irrigation', ofcourse, *petta* farmers give their unreserved support to raising the tank bund.

Fig. 1 Stake holders in a Rajasthan Tank

Petta cultivators' interests, thus, are generally in direct conflict with command area farmers. They like siltation in the tank-bed; command area farmers do not. *Petta*-cultivators want the tank emptied by end-September; command area farmers, at least near the head want the tank to hold water so that they can get

three full irrigations in rabi season. *Petta* farmers have no interest in the rehabilitation, particularly of the canal system; command area farmers have a strong interest in it. Existing *Petta* farmers near the dam loathe the idea of desilting the tank-beds because their lands will not dry in time for a rabi crop; distant *petta* farmers⁵ prefer raising the bund height to desilting the tank bund near the dam, and the command area farmers prefer desilting over raised bunds. *Petta* farmers are probably a strong interest group in tank management; else, it is difficult to understand why the practice of 'inundation irrigation' is so much in vogue. There are other stake holders, too. Fishing communities' interests differ from those of both these; they have no interest in canal rehabilitation; they want raising of the bund but abhor inundation irrigation; they do not have a powerful voice, but in Panchayat (Village Council) managed tanks where fishing contracts are awarded to private contractors, they are often able to influence or even dictate the water release policies.

3.3 Extensification

The Irrigation Department's tank management strategy—dominated by management practices popular in large irrigation systems-- has tended to favour intensive, orderly gravity flow irrigation in the officially designated command. In the past, when the Irrigation Department was able to manage tanks more closely than it does today, farmers in the official command received upto 12-15 thousand cubic meters of water per ha and could grow water loving crops which would be considered an anachronism in this water-scarce region. But this has changed as a result of pressures for extensification.⁶ The GoR strategy is suspicious

⁵ That is, those in the periphery of tank-bed whose lands get submerged only in years of high rainfall.

⁶ Not very long ago, for instance, small commands of many tanks in Bhilwara and Tonk districts—such as Mandal and Lamba—had substantial sugarcane cultivation; today, sugarcane has been replaced by wheat and mustard over a larger but sparsely irrigated area far beyond the official command. In a tank called *Pechi-Ki-Bavri* we visited at Sailadutta village, Hindoli Tehsil of Bundi district, we found that the effective command area had expanded nearly 100% over the last decade; and groundwater irrigation had replaced the second and third rounds of gravity irrigation from tanks. The net effect was that some 1/3rd of the command, especially near the head grew sugarcane in mid-1980's; but now there is none. Not too long ago, for instance, small commands of many tanks in Bhilwara and Tonk districts—such as Mandal and Lamba—had substantial sugarcane cultivation; today, sugarcane has been replaced by wheat and mustard over a larger but sparsely irrigated area far beyond the official command. In a tank called *Pechi-Ki-Bavri* we visited at Sailadutta village, Hindoli Tehsil of Bundi district, we found that the effective command area had expanded nearly 100% over the last decade; and groundwater irrigation had replaced the second and third rounds of gravity irrigation from tanks. The net effect was that some 1/3rd of the command, especially near the head grew sugarcane in mid-1980's;

towards the pressures for extensification that are built into the natural evolution of tank systems over recent decades. Curiously, despite problems of siltation of tank-beds, poor maintenance of head-works and distribution systems—all of which must reduce the design command—the actual areas served by many tanks have slowly increased far beyond what was originally the design command. This has happened in a number of ways: first, of course is the tank-bed cultivation which even today is not counted in the benefit-cost calculus of the Irrigation Department. Then, commonly, the ends of the canals have got extended by the farmers on the fringe of the design command to serve more land by flow irrigation. Initially, their owners were viewed as ‘unauthorised encroachers’; over the years, they got established as part of the official command. In old tanks, many fields inside the official command were initially left fallow and therefore excluded from the design command; with growing pressures of population and commercialization, their owners began irrigating these fields; being inside the command, they had little difficulty staking claim to tank irrigation. Then, there were traditional well-irrigators inside the command; these too were viewed as ‘non-command’ while fixing the design command; some of them deliberately opted out to evade assessment for irrigation fees; but once within the command, there was no stopping these from using the flow irrigation. Finally, there are up-lying lands within the command where gravity flow can not reach; many of these have dug *dora*’s (small ponds) which they fill with tank water and then lift it to irrigate their up-lying fields using long (often 1.5-2 km) flexible pipes. In some tanks we visited, farmers enforced the department norm that such farmers can lift water only using traditional bullock driven devices; but in many others, we saw them irrigating freely with diesel pumps.

but now there is none. And everyone has now switched to wheat and mustard in rabi (winter). In Maharashtra, another water-scarce state in Western India with large areas under sugarcane cultivation, many studies have shown that water-loving crops such as sugarcane generate less income, employment and food security per m³ of water compared to many other crops, especially, cereals, oilseeds and pulse crops. Based on this, Gram Gaurav Pratishthan, a NGO organising farmers around small water projects called *Pani Panchayats* (Water Councils) made it a precondition that water will not be used for sugarcane and banana cultivation (see, e.g., Chambers 1981; GGP 1983; Deshpande n.d.; Kohle et al. 1986; Morehouse 1987).

3.4 The Recharge Factor

Another major group of stake-holders in tanks are well owners on the tank-bed as well as in the command. The ID engineers and head-reach farmers bemoan the heavy seepage losses during storage as well as conveyance of water—one of the main points of attack of the proposed rehabilitation strategy. However, except in areas with problematic geology including impermeable soils, through out our fieldwork, we found that improved productivity of wells due to groundwater recharge is by far the most valuable benefit farmers associated with the tanks (see, e.g., UN 1998; GoR 1999)⁷. In Govindgarh tank in Ajmer district, farmers we interviewed asserted that that is the reason why rising land values in the aftermath of the construction of a new tank is by no means limited to tank bund and command areas but extends to the entire domain influenced by groundwater recharge due to the tank. Even farmers without wells feel better off with tank-recharge because of improved prospects of accessing purchased well irrigation; as one of them said ‘*Kuen valon ki gulami sarkar ki gulami se badtar nahi.. kam se kam vo hota to hai ke tum jaa ke uske paon pakado*’ (being at the mercy of water sellers is by no means worse than being at the mercy of the Sarkar (Irrigation Department); at least, the water seller is around for you to fall to your knees before him..”). If farmers did not feel bitter about only one or two flow irrigations provided by the tanks in most years, it was because an ingenious and vibrant system of conjunctive use of surface and groundwater operates in most tanks. True, private investment in wells has been slow in coming, what with the general pump capital scarcity in the region; however, pump irrigation markets are extensive and vigorous particularly in the neighbourhood of tank-bunds. Purchased well irrigation is expensive⁸; yet

⁷ That improved productivity of wells due to groundwater recharge is the major benefit of new and rehabilitated tanks is supported by many studies throughout India (see, e.g., Shah et al forthcoming; Kulandaivelu and Jayachandran 1990; Reddy, Rao and Prakasam 1990; Shah 2000b).

⁸ Pump irrigation sells at Rs 35-40/hour (US \$ 0.9-1) from 5 hp diesel pump-sets; flexible pipes are leased out to water buyers by the well owners at Rs 20 (US\$0.5)/100 feet/day. At Rs 500-750 (US \$ 12-18) for a single watering per ha, purchased groundwater is indeed expensive irrigation compared to Rs 175 (US \$ 4.3)/ha for 2-3 flow irrigations from tank. And yet, farmers seem to prefer it. Most likely, this is because of the greater control and reliability that pump irrigation offers compared to canal irrigation which in any case is seldom sufficient to fully irrigate any crop other than gram or *raido* (mustard). And wells, once recharged, offer these control and reliability. The pump owners we met in Gobind Gadh in Ajmer were keen that the Department permits pumping from the canal or the reservoir; they were willing to pay even Rs 200/bigha (Rs 1000/ha) for such irrigation compared to the standard Rs 175/ha for flow irrigation

groundwater is the mainstay of the farm economy in tank-surrounds because it offers reliability, timeliness and control that flow irrigation from tanks does not. Indeed, there might be value in thinking of irrigation tanks primarily as percolation tanks designed to maximise groundwater recharge over as large an area around the tank as possible. In areas with confined aquifers with rock stratum at 40-50 feet below ground, the relationship between the level of tank storage and water level in the wells is visible and direct.⁹

3.5 Catchment Encroachment

Finally, a problem that the present tank rehabilitation strategy does not address at all is the declining water input into many tank systems. A major factor behind this has been the growing profusion of all manner of water harvesting and storage structures up-stream of the tanks and their downstream. Most of these were not there when the tanks were originally planned and designed. This may be partly because the population density was lower, and so was the demand for water up-stream, and partly because there has now been a major campaign to increase water harvesting, in the name of ‘watershed management’. However, as population and water demand have increased in the catchment, a variety of new structures –*anicuts*, *johads*, *pals*, etc have come up under individual or group initiatives with support from government programmes as well as NGOs. With this, the free catchment available to the MI tanks has declined and so has their input of rain water run off. The Irrigation Department has not taken a kind view of this; and the Rajasthan Irrigation Act empowers the state to prohibit such structures above a certain size in the catchment of existing tanks (GoR nd); however, in our understanding, no move has been made so far to check the growth in such structures.¹⁰ From the technical viewpoint, the department’s sense of unease with

(although he was sure that no one would come to collect it). But he was sure that if such permission were given, farmers would be happier and would have better control over irrigation. There are important questions of equity involved since head reach farmers can intensively use abundant and cheap flow irrigation to grow crops like *methi* (fenugreek) and wheat while tail-enders have to make do with the costlier groundwater to grow only mustard or *taramiri* (a minor oilseed).

⁹ In many tanks, farmers described the relationship with high level of accuracy; in one of the tanks we visited in Tonk, for example, farmers told us that when the water level in the tank moves between 5 and 12 feet either way, the water level in their wells moves directly with it and on a one-to-one basis.

unchecked growth in such structures is clearly understandable; but from the larger socio-ecological perspective, NGOs like Tarun Bharat Sangh argue differently: each MI tank uses up a catchment of 30-50 sq km, claims its precipitation and assigns it to a small command belonging to 300-400 families; decades ago when some of the existing MI tanks were built, the bulk of their catchment area was uninhabited and water demand in the catchment area was probably negligible; in that scenario, it was arguably appropriate to capture and assign the rainfall precipitation of a vast catchment area to serve a small group of families. However, that is no longer the case today; and residents of the catchment areas assert their right to capture some of their own rainfall for their use rather than forgo it in order to fill up tanks downstream built under different conditions decades ago. Some of the new social formations around water-- such as the *Swadhyaya* movement in water-scarce Gujarat --are promoting a new 'water ethic' amongst people: 'rain falling on your roof stays in your house; rain falling in your field, stays in your field; rain falling in your village, stays in your village.' (see, Shah 2000). The profusion of small *johads*, *pals* and ponds that has come up in Rajasthan in some ways operationalizes this ethic; whereas huge tanks with protected catchments serving a small command area in a water-scarce state like Rajasthan challenge such an ethic.

This sets into motion an interesting dialogue between the western notions of rights based on riparian notion and/or prior appropriation and the notion of rights on rainfall precipitation based on the *Swadhyaya* ethic that is gaining popularity throughout western India. It is early to say which way this debate will go.

However, it is clear that notions of riparian rights and prior appropriation make sense in countries like the US, New Zealand and Canada where: [a] users compete for 'diverted' flows of water, [b] population density is high around and towards the end of the rivers but the catchment areas are sparsely populated (often 1 person or less per km²), and [c] rainfall precipitation received over several months combined with low temperatures and low wind-speeds cause very low losses through evapo-transpiration and result in

¹⁰ It did intervene once apparently when Tarun Bharat Sangh, an NGO built a series of *pals* and *johads* in Alwar district; but the NGO mobilised massive public support, took the issue to the court and even had it raised in the Legislative Assembly of the state. Finally, the ID had to drop the issue.

high run-off coefficients. In semi-arid regions of South-Asia, opposite conditions obtain: [a] here population density tends to be high downstream as well as in the catchment areas (300-400 persons/km²); [b] monsoon rainfall is received over a short period—in India, in less than 100 hours of precipitation; [c] this has to be conserved and stored over November-May period every year in conditions of high temperatures and wind-speeds that cause very high ET losses. As water scarcity grows in Western India, the competition is no longer for captured or flowing water; it is for rainfall precipitation itself—which is why the slogan ‘rain on your roof stays on your roof...’ has won ready popular support here in favour of the notions of riparian rights and rights based on prior appropriation. It is in support of this ethic that the New Delhi based Centre for Science and Environment adopted ‘*Everyone Lives Downstream*’ as the credo of its campaign at the World Water Forum that met at the Hague in March 2000 (see, e.g., Shah 2000).¹¹

Be that as it may; as rain water captured, conserved and stored in a macro-watershed approaches the total precipitation, such competition between water harvesting structures is only to be anticipated. In many macro-watersheds—such as the Ruparel river basin in the Alwar district of Rajasthan—where the entire basin has been saturated with a variety of small and large, private, group, and community owned water harvesting and storage structures, the condition is already being approached where increased water input and storage in a large tank must reduce the availability of water in water harvesting structures downstream; and by the same token, construction of new structures upstream directly affects the water income in the tank downstream. In such situations, rehabilitating an isolated tank would hardly help; it will only transfer benefits from one

¹¹ Center for Science and Environment has also adduced evidence to show that diverting rain water in a large number of small water harvesting structures in a catchment captures and stores more of the scarce precipitation closer to the communities in these parts of the world than having a large reservoir downstream (Agarwal 2000). For instance, Agarwal cites evidence from Negev desert in Israel to show that 3000 micro-catchments of 0.1 ha capture 5 times more water than a single catchment of 300 ha, and this multiple increases in a drought period (p:9). He also cites results by Micheal Evanari, an Israeli scientist that show that ‘While a 1 ha watershed in the Negev yielded as much as 95 cubic meters of water per ha per year, a 345 ha watershed yielded only 24 cubic meters/year. In other words, as much as 75% of the water that could be collected was lost. This loss was even higher in a drought year.’ Agarwal cites Evenari: “...during drought years with less than 50 mm of rain fall, watersheds larger than 50 ha will not produce any appreciable water yield while small natural watersheds will yield 20-40 cubic meters per hectare and micro-catchments (smaller than 0.1 ha) as much as 80-100 cubic meters per hectare”. This is because ‘water collected over larger watersheds will have to run over a larger area before it is collected and a large part will get lost in small puddles and depressions, as soil moisture and evaporation’.

community to another. If order is to be brought in this chaotic race to capture water, new and more complex rules would be needed that encompass the watersheds and entire river basins. Many have already begun to question Irrigation Department's assertion that the catchment of older and bigger tanks should be protected because they were there before others came or because a lot of investment has gone into them.

The viewpoint of groundwater users also needs to be incorporated in tank strategies. Well owners in the recharge zone invariably know that the way the tank is managed does affect the productivity of their wells in a direct and significant manner; however, groundwater users in the neighbourhood of a tank are not counted as the stake-holders; neither do the operational managers from the Irrigation Department—the *mistry* (technician), *beldaar* (water delivery man) or even junior engineer—treat them as part of the 'publics' interested in the tank. It is easy to create a false sense of clarity by restricting the analysis of the impact of the interventions carried out in a tank system—such as a rehabilitation that increases its storage-- only on the farmers in its command area; however, such analysis will only result in strategies and management practices that excluded groups will relentlessly strive to frustrate.

4. Tanks in a River Basin Perspective: Lessons from NGO Experiments

NGOs, which have done some outstanding work with tanks in Eastern Rajasthan, have intuitively come to grips with the pitfalls of taking the narrow view and have placed much emphasis on the variety of roles tanks play in their socio-ecologies (see, e.g, Mishra 1993, 1995). Of particular significance is the work by PRADAN with *paals* and of Tarun Bharat Sangh with *johads*. *Paal* and *Johad* are alternative local names for the same water-harvesting and storage structure used in Rajasthan over centuries. We briefly describe their experiments and draw some useful lessons for enhancing the social value of tanks in the semi-arid and arid conditions of Rajasthan.

PRADAN operates a rain water conservation project in Alwar district that aims at the revival of the traditional *Paal* system of rain water harvesting. In Hindi, a *paal* is a bund built along a contour and in many ways is a miniature version of a tank but without sluice gates and canals.¹² Starting work on isolated *paals* several years ago, PRADAN discovered early the value of working on a system (or cascade) of *paals* covering an entire micro-watershed to internalize the externalities and maximize the benefits.

PRADAN has helped village groups build over 110 *paals* in Alwar in several micro watersheds it identified in three blocks, keeping in view the macro-watersheds or basins of which these are parts. A series of *paals* is built in a zigzag manner in a micro-watershed to capture and impound the floods flowing downstream with great velocity and force. *Paals* prevent massive soil erosion that flood waters cause, making the plains as bare and rocky as the surrounding hills; by reducing the velocity and force of rain water run-off, they greatly reduce the pressure that the floods would place on the dams constructed downstream; they make the flood waters spread over a larger area than happened earlier; and each *paal* forms a mini-tank of shallow depth; water stays for 50-60 days during which 50-60% percolates to the aquifer while the rest gets evaporated. The last two ensure large-scale recharge of groundwater aquifer and facilitate well irrigation.

The direct benefits of *paals* accrue to farmers in the tank bed *above* the *paals*. Their land accumulates silt and becomes fertile, needing little fertilisation. Farmers above the *paals* sow their crops as the land becomes emptied of water; and a crop like mustard grows entirely on the moisture retained in top soil.

Wheat requires 1 or 2 waterings over the rainfall. But the wells get so amply recharged that well irrigation

¹² A typical *paal* is made of earth, around 8-12 feet high and around 12-15 feet wide at the base; some of the *paals* we saw in the course of our field work were 80-100 meters long. Grass or vegetation is grown along the sides so that soil erosion is minimized; and the top of the bund is used as a cart road. *Paals* have been built and used by farmers for ages; however, for a number of reasons--including the rise of groundwater irrigation in the area--traditional water harvesting and irrigation structures have increasingly fallen into disuse. A very important reason was the migration to Pakistan, at the time of India's Independence, of the *Miya* community whose members, for generations, were enthusiastic builders and keepers of *Paals*. With their departure have gone the skills and the enthusiasm for *paals*. Farmers have ignored the repair and maintenance of the *Paals* for decades. As a result, along with this ingenious structure, there has also been the threat of decline in the traditional science of siting and building *Paals*. PRADAN has not only tried to revive and improve upon the technique but also to get it recognition as part of the corpus of watershed management technologies.

becomes extensive. In a cascade of seven *paals* in Kishan Garh, one of the clusters of villages where PRADAN work has matured, the static pre-monsoon water table in open wells has risen to 8 meters from the earlier level of 25-27 meters for as long as the well owners in the area could remember. Before, wells could be pumped for hardly any length of time, and had to be left to recoup for days before they could be pumped again for an hour or so; now the wells can be pumped for hours on end without water level in the wells falling appreciably. A number of abandoned wells have been revived; many farmers with electric pumps had earlier disconnected their motors; but they have now begun pumping again. Pump irrigation markets have sprung up; and a good deal of irrigation occurs against 1/4th crop share. 12 out of 13 blocks in Alwar have been declared dark with over-exploited groundwater¹³; *Paals* are in many ways an ideal device to ameliorate Alwar's groundwater over exploitation problem.

PRADAN has learnt three important lessons: first, groundwater recharge is probably the most valuable benefit of their work with *paals*; second, the sum total of benefit created by *paals* grows exponentially as the density of *paals* increases in a watershed; third, it is difficult to create a sustainable farmer organisation around *paals* without understanding and harmonizing conflicting interests of multiple stake holder groups.¹⁴ This last is important. For, despite intensive and time-consuming 'process' work, PRADAN is still unhappy with farmer participation in its *paal* project. Farmers recognise the benefits of building *paals*; but are still unable to secure the interest-harmony needed to organise to maintain the *paals* in proper condition. Where PRADAN built clusters of *paals* as in Kishan Garh, however, they found that

¹³ The Central Groundwater Board of India classified areas into 3 categories based on the extent of development of groundwater resources. White areas are those that use less than 65% of their annual recharge; Grey areas use between 65 and 85%; and Dark areas are those that use over 85% of their renewable groundwater resource.

¹⁴ In traditional *paals*, farmers did not build spillways; instead, during floods, they would cut the *paal* to let the water spill over. But this was often dangerous; farmers often cut the *paal* too late; in the meanwhile, water began overflowing the *paal* virtually washing it away. The *pucca* spillway PRADAN now builds deals with this problem; but farmers are still unsympathetic to the *pucca* spillway. The farmer below the spillway almost always objects because his field will face the floods with full fury. Farmers above but further upstream from the *paal* too are not very keen because the spillway reduces their submergence area. Farmers too far below the *paal* are in any case not interested; they are too far from the next *paal* downstream to be in its submergence area; and the *paal* upstream will provide them no water except through well recharge. PRADAN tried helping them lift water from the tank for early irrigation; but farmers above the *paal* would not readily agree to give away their water.

the entire community developed a new interest in the technology because all the wells in the watershed were benefited. Wells then became the rallying point for the *paal* program. Therefore PRADAN has gone further upstream in its organizing efforts. For each micro-watershed, they have formed a *Samiti* (Committee) that includes all members benefited by the *paals*; in Kishan Garh block, 14 such *Samitis* have been formed into a Federation with a broader mandate than just building and maintaining *paals* which includes savings and credit, extension support, fertiliser and improved seed supply and so on.

Tarun Bharat Sangh (Young India Association) (TBS), another NGO which has done some excellent work in water harvesting and management in this part of Rajasthan has achieved what most NGOs want but fail to achieve—scale of impact. TBS works at the level of Ruparel river basin—in roughly 550 villages spread over 5 sub-divisions of Alwar district. Their water harvesting work covers approximately 6500 square kilometers area. Therefore, its impact is visible and generates powerful demonstration effect on the people living in the area.¹⁵ Early in its work, TBS learnt that scale begets scale. Once the benefits of *johad* development work become visible and talked about amongst villages, demand for similar work comes forth on its own; and once a demand system gets created, half the job of eliciting farmer participation gets done. So TBS ended up building large clusters of *johads* in the areas where they began work in 1985. It is these clusters, encompassing entire watersheds, rather than individual *johads* that have produced dramatic impacts on farm economies as well as the hydrology of these areas. Again, groundwater recharge has been

¹⁵ Like PRADAN, TBS too has been working with a variety of water harvesting structures including *bandh* (bunds), *johads* (small ponds or reservoirs), *medbandhi* (farm bunds) and others. However, the centre-piece of their work has been the *johad* and TBS has already helped village communities to build these in thousands. A *Johad* basically is no different from the *paal*. Its purpose is to check rain water in *nalas*, impound the water so checked for 50-60 days while the land in the submergence area ‘soaks in the water, quenches its thirst and fills up its stomach as camels do in the Thar desert’ (as a local farmer explained to us). Spill-ways called *uparahs* are provided to allow excess water to overflow. After the water dries up, crops are grown in the *petta* lands; and wells get recharged so that additional irrigation becomes possible.

central to TBS success (see, e.g. GOR 1999: 8) ¹⁶. Wells which a few years ago were completely dry or could be hardly pumped an hour a day now abound in water and can be pumped for as long as farmers need them. Several small rivers and numerous natural *nalas* (drainage ways) that had dried up for decades have suddenly sprung to life and many flow perennially (Patel 1997; Singh 1996) . Farms which had not been cultivated and given up as wasteland have begun growing crops like *sarson*(mustard), wheat, and *makka* (maize). To TBS's worry, some sugarcane cultivation has begun, too. Many abandoned wells have been recommissioned. And an area which had become a basket case has become green once again and is poised on the road to rural prosperity. Land values in many TBS areas have shot up from US \$ 2000-2400 a ha to US \$9000-10000 per ha. And in 1999, the President of India visited one of the TBS villages to give a water harvesting award to its people.

A major ecological impact of *johad* concentrations has been in reducing the impact of both floods as well as draughts. In the areas of Alwar district which has dense concentrations of TBS supported *johads* and other water harvesting structures, the effect of the 1996 flood was minimal or absent all together; elsewhere, floods devastated villages, destroyed *pucca* bunds and in general created great havoc (Ravi and Jain 1997; Singh 1995; Singh nd). So their earlier surmise that *johads* are effective draught-proofers was surpassed by this experience. A dense system of *johads* cuts the pace and fury of flood waters that race down the hills with great pace and force, and thus preempt what might otherwise become a flood.

TBS's work also offers important insights about a strategy of scaling up in which people take large and growing initiative (TBS nd). First is its organisation design; TBS has its own core staff of less than 100, but has several hundred volunteers chosen from the villages where they work (and paid a modest honorarium). Many members of the staff have spun off into small grassroots organisation; and the TBS

¹⁶ TBS has waged a running battle with the Rajasthan State Irrigation Department since its inception; yet, a study carried out by the Department confirmed that , ' The important ingredients of the T.B.S activity have been to: [a] increase in groundwater recharge which can be referred to as artificial recharge. As a result, water table in the wells has risen; [b] river in semi-arid region has changed from ephemeral to perennial.' (GOR 1999: 8).

has extended support to these. Second, they have been able to catalyse wide-spread public interest; they enter a new village only on farmer demand and that too after ascertaining broad-based local support for the initiative. Over the years, they have evolved a set of norms and rules that have become standardized. For example, people who benefit always have to contribute all the labour needed; they also contribute some material and cash. TBS tops this up with financial support for hire of tractors and cement. Besides, TBS's own 'home-grown' engineers also provide crucial help in community organisation process, in surfacing the needs and concerns of participating members and evolve a design of the structure that addresses these. Each *johad* then is differently designed to fit the unique needs of each site and group. Third, TBS's works are cheap compared to government structures. A couple of middle-sized *pucca bandhs* (dams) we saw just off the TBS campus in the village of Bikhampur (No: 75 and 76) cost only around Rs 30000 (US \$ 700) each besides farmers' contributions. The same *bandhs* (dams) would have cost US \$ 10000-15000 at least had they been built by the department. Finally, TBS's work offers eloquent testimony to the value of building *johads* in clusters and how they achieve a certain measure of interest-harmony amongst conflicting stake holder groups. In three *johads* we visited in 1998 *rabi* (winter) season, surrounding areas had become lush green and *sarson* (mustard) yellow; wells had water at 3-4 meters; the number of diesel pumps has begun soaring, and small streams and rivulets that had disappeared had begun flowing all over again. The traditional institutions of managing water harvesting structures are beginning to get revived pretty much on their own; and there is a community-wide dialogue on ways of sustaining and enhancing the water retention.¹⁷ Recently, interesting new developments took place on the institutional front. Farmers along the 30 km long Arwari river (in the Ruparel river basin) which got revived thanks to TBS's concentrated *johad* campaign have formed the Arwari River Parliament with representatives elected from each village. The River Parliament has already formulated a set of norms embodying a new 'water ethic' which, for instance, bans the cultivation of sugar cane in all the villages and imposes restrictions on pumping of wells at certain periods. It is early times to assess the significance

¹⁷ In Hammirpur tank, for instance, the land under the *bandh* belonged to a private farmer; the village Gram Sabha persuaded him to give his land for building the *bandh* and compensated him by creating a new holding by cutting up

of this institutional development; however, Arwari River Parliament may well be the first spontaneous, grass-roots river basin institution in India.

5. Towards an *Appropriate* Tank Rehabilitation Strategy?

The present strategy of the Government of Rajasthan for improving the productivity of tanks is based on an unduly limited view of the role of tanks. It tends to view tanks as pure gravity-flow irrigation systems, the tank's primary function to be to provide flow irrigation; and the officially recognised command area farmers as its sole target group or customers of tank rehabilitation programs. As a result, it tends to judge the success or failure of a tank system in terms of its performance in providing gravity flow irrigation service to the command area farmers. It treats tank-bed farmers to be outside its purview, takes note of the dependence of groundwater users on the recharge from tank but does not include them either as beneficiaries of the system or as its customers. This is why no water fees are applied either to tank-bed cultivators or well irrigators, nor is there an attempt to include these groups into Water User Associations. The present strategy is also unsympathetic—or, at best, agnostic-- towards water users up-stream as well as downstream of a tank. That this perspective dominates the government strategy is evident in the absence of any analysis of the potential impact of rehabilitation on other groups likely to be affected—downstream users, groundwater users, and tank-bed cultivators.

However, as providers of flow-irrigation, MI tanks are probably not very attractive and dependable structures any way. In point of fact, our assessment is that except around 1/3rd of the command area farmers with lands in the head-reaches of the tanks—who can take 2-3 irrigations for their rabi crops even during the years of poor rainfall, by far the majority of the farmers in the middle and tail reaches can not depend upon the tank to get all the flow irrigation they need. If they are able to take a rabi crop with just one or at best two irrigations, it is because they pursue a very irrigation-inelastic cropping regime based on mustard or millets which can give moderate yields with just one wetting and because they use supplementary groundwater irrigation.

small pieces from the lands belonging to farmers in the submergence area.

Contrasting the flow-irrigation system perspective by a broader, more nuanced socio-ecological perspective leads to a different understanding of the role tanks play in the lives of the people around them. It also leads us to a radically different notion of the kind of rehabilitation that will enhance the relevance and overall social value of tanks, and offers new insights on the strategy of management turn-over that is best likely to make sense given the diverse interests and varied stake-holder groups in the tanks as of today. In our assessment, the rehabilitation program should be based on an alternative conception of MI tanks as socio-ecological constructs whose benefits, besides flow irrigation in the command area, include groundwater recharge in the entire neighbourhood of the tanks (in a radius of as much as 20 km² in some tanks), *petta* cultivation, fisheries, besides serving non-agricultural demand for water—such as domestic uses, livestock, industry. Moreover, in many river basins, there seems to prevail an ecological equilibrium that represents years of mutual adaptation by a variety of water users and water conservation structures built by them both upstream as well as down-stream; and it may be difficult to make significant improvements in one part of the watershed/basin without adversely affecting other parts.

Real improvement in the productivity of Rajasthan's tanks can occur only through a basin-wide intervention that searches for genuine win-win opportunities. The present strategy falls short of doing this; and therefore, it is not clear whether net benefit of tank rehabilitation would be *positive*, leave alone large enough to justify the investment it entails. By increased storage through de-silting or raised bunds, for example, it may become possible to provide three irrigations to the official command compared to one as at present; but if this means that half the submergence area of the tank belonging to *petta* farmers can not take a rabi crop, the gain in the command area can be more than nullified by the loss in the *petta* cultivation. And things may get worse if the area near the head reach gets water-logged due to over-irrigation and excessive return-flow, as indeed is the case in some of the tanks. Similarly, lining of canals may increase the velocity and out-reach of flow irrigation; but if it reduces the recharge of wells in a significant measure, the net benefits of lining may be greatly reduced. Then, if rehabilitation of MI tanks

makes numerous small *johads* downstream useless and unproductive, the tank command farmers may benefit from rehabilitation but many other farmers may lose, for no fault of theirs. Whether in fact downstream farmers will lose with increased storage in MI tanks, or whether well recharge will be affected by canal lining, or whether *petta* cultivation will be reduced with raised tank bunds or whether the benefits in the command area will be far greater than losses to other stake-holders affected by rehabilitation are all empirical questions. And the ID do not have even tentative answers to these questions. The present strategy does not even address such issues as: what is the extent of water-loss in tank storage versus aquifer storage due to evaporation? What are the groundwater recharge coefficients in lined and unlined water conveyance systems? What is the pattern of distribution of run-off capture and storage in different water harvesting and storage structures in a basin? How big are the recharge zones of different tanks? What proportion of tank storage loss is explained by evaporation and groundwater recharge? We believe that incorporating technical relationships such as these is absolutely essential before any sensible planning of tank rehabilitation can begin. All these suggest that an approach that is likely to be most effective in such a situation is not the blue-print one that underlies the current strategy but a learning process approach that lays great stress on experimenting with alternative ways of improving productivity of tank systems, and closely studying the implications of each. Such an approach can result in improved management of water resources provided it recognizes multiple stake holders, conflicting interests, complex structure of rights and obligations in tank systems; and provided it views each tank against the larger perspective of its watershed and its river basin.

References:

Agarwal, Anil. (2000). *Drought? Try Capturing The Rain*, Delhi: Center for Science and Environment.

Raju, K V and Tushaar Shah.(2000). 'Revitalisation of Irrigation Tanks in Rajasthan', *Economic and Political Weekly*, vol XXXV, No 23, June 3, pp:1930-1936.

Chambers, Robert. (1981). "Gram Gaurav Pratishthan, Naigaon, Pune District: Notes and Reflections on a field visit", New Delhi: Ford Foundation (typescript).

Derashree, D D (nd) 'Sardar Nagar Tank Management: An Example of PIM', Bhilwara: unpublished paper.

Deshpande, V.D. (n.d). "Pani Panchayat: A Movement to Secure irrigation facility to poor farmers", Pune: Indian Institute of nEducation (mimeograph)

- FAO (1997) *Modernisation of Irrigation Schemes: Past Experience and Future Options*, Water Report #12, Bangkok: Food and Agriculture Organisation.
- GGP. (1983). *Pani Panchayat: Dividing Line between Poverty and Prosperity*, Naigaon, Maharashtra: Gram Gaurav Pratishthan.
- GOR. (1996) *Agricultural Statistics-Rajasthan: 1995-96*, Jaipur, Yojana Bhawan.
- GOR. (1997a) *Rehabilitation Project of Minor Irrigation Tanks to be Posed for External Assistance*, Director, Minor Irrigation Schemes, Irrigation Department, Jaipur.
- GOR. (1997b) *Rehabilitation Project of Minor Irrigation Tanks of Rajasthan: Presentation before Representatives of Germany, EC, Switzerland, Netherlands, Denmark, Sweden & France*, Director, Minor Irrigation Schemes, Irrigation Department, Jaipur.
- GOR.(nd) *Rajasthan Irrigation and Drainage Act, 1954*, Jaipur: Department of Irrigation.
- GOR. (1995) *Rajya Ke Paramparagat Jal Sroton Ke Punaruddhar tatha Nirman Taknik mein Sudhar Hetu Karyadal ka Prativedan*, Jaipur: Department of Irrigation.
- GOR. (1998). *State Water Policy*, Jaipur: Irrigation Department (mimeo).
- GOR. (1999). 'A Study of the Impacts by the Small Water Harvesting Structures in the Catchment area of Sainthal Sagar Dam', Jaipur: Government of Rajasthan, Investigation, Design and Research (Irrigation) Unit.
- Kalu, Indra Lal. (1998) 'Modernization of Irrigation System Operation: Institutional Development and Physical Improvement', in D. Renault (eds) *Modernisation of Irrigation System Operations*, Proceedings of the Fifth International IT IS Network Meeting in Aurangabad, India, 28-30 October 1998.
- Kolhe, A.K, S M Deshpande and J G Gore. (1986). "Pani Panchayat: An Overview", Development Group, "Yashowdhan", Vijayanagar, Pune 411030, Maharashtra.
- Kulandaivelu, R and K Jayachandran. (1990). Groundwater Utilisation and recharge through Percolation Ponds-A Case Study, *Percolation Ponds: Pre-Workshop volume*. Madras, India: Center for Water Resources, 1990. Pp.21-25
- Mishra, Anupam (1993) *Aaj Bhi Khare Hain Talab*, Delhi: Gandhi Peace Foundation.
- Mishra, Anupam (1995) *Rajasthan Ki Rajat Bunden*, Delhi: Gandhi Peace Foundation.
- Morehouse, Ward. (1987). "Levitiation Revisited: Small-scale Lift Irrigation Technology and poverty alleviation", *Development Forum*, June, pp. 8-9.
- Patel, Jashbhai (1997) *Story of a Rivulet Arvari: From Death to Rebirth*, Bhikampura: Tarun Bharat Sangh.
- Planning Commission. 1999. 'Status of tank irrigation in India', New Delhi: Planning Commission, Government of India, September (mimeo)
- Ravi, Rajesh and Jinesh Jain (1997) *Baadh se Mukti Tak Adhyayan*, Bhikampura: Tarun Bharat Sangh.
- Reddy, N, KSV Rao and P Prakasam (1990) 'Impact of Percolation Ponds on Groundwater Regime in Hard Rock areas of Andhra Pradesh', in *Percolation Ponds: Pre-Workshop volume*. Madras, India: Center for Water Resources, 1990. Pp.137-144
- Renault, D.(1998). Modernization of Irrigation Systems: A Continuous Process, in D. Renault (eds) *Modernisation of Irrigation System Operations*, Proceedings of the Fifth International IT IS Network Meeting in Aurangabad, India, 28-30 October 1998.

Shah, Tushaar. (2000a). 'Mobilizing Social Energy against Environmental Challenge: Understanding Groundwater Recharge Movement in Western India', *Natural Resource Forum*, 24(2000) 197-209.

Shah, Tushaar. (2000b). 'Limits to Leapfrogging: Issues in Transposing Successful River Basin Management Institutions in the Developing World', paper presented at the IWMI-DSE Conference on 'Institutions for Water Management in Water-stressed River Basins', held at the Loskop Dam, South Africa during 16-21 October.

Shah, Tushaar, R Seenivasan, C R Shanmugam and M P Vasimalai. (forthcoming). 'Sustaining Tamilnadu's Tanks: A Review of Issues and Approaches' in Dinesh Marothia (eds) *Institutionalizing the Commons*, New Delhi: Concept Publishing Company (forthcoming).

Singh, Rajendra (1995) *Lok Parampara Se Mila Rasta*, Bhikampura: Tarun Bharat Sangh.

Singh, Rajendra (nd) *1996 Floods of Barah Basin: A close Genesis*, Bhikampura: Tarun Bharat Sangh.

Singh, Vir (1996) *Rejuvenating the Ruparel River*, Bhikampura: Tarun Bharat Sangh.

Tarun Bharat Sangh (nd) *Jalagan Vikas ke Ayam*, Bhikampura: Tarun Bharat Sangh.

UN. (1998). '*Johad: Watershed in Alwar District, Rajasthan*', New Delhi: UN-Inter Agency Working Group on Water and Environmental Sanitation.
