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A survey of community based water storage structures and their management in Gujarat, India.

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Factors governing hydrological and institutional factors define policy intervention in the management of community based water storage structures (CBWS). Institutional factors have a direct bearing on the functioning of CBWS and also interact with physical and technical factors to influence their sustainability. The present study attempts to examine sustainability of CBWS to draw policy implications in Indian context. The study revealed that financial viability of CBWS was affected by Panchayati Raj Institution (PRI) functionality, perception about change in water collection time and number of households served by the water resource significantly. Similarly factors like accessibility and use restriction with respect to the CBWS significantly affected the CBWS functionality. It was concluded that, in Indian context, PRI functionality in respect of community resource management needs to be addressed for both financial viability as well as functionality of CBWS. This could be achieved through better representation of women and weaker section of the community in management of these resources as these sections of society are largely affected by their management. Factors such as use restriction of community water source which affects the physical status of the resource and storage to catchment ratio, which affects operational status of the source, are critical while designing location and size of the community water resource such as pond.

Key words: Community, water storage structures, management, common property resource.

INTRODUCTION

Community based water storage (CBWS) structures are water bodies which are managed by rural community for distribution of benefits to locals. These village surface water bodies are small water-storing structures basically meant for catering to the domestic water needs of the village community. These are good source of water, particularly in areas that receive low rainfall and where livelihood is mainly based on rain-fed agriculture. These

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are structures, with rain water accumulation in low lying areas of various depths, having a catchment and slope where water is collected during the monsoon period. These water bodies have always remained the common property resource (CPR) with basic philosophy of water for all in the rural areas.

Water management traditions in India

In the rural localities, irrespective of the existing social diversities, water has been regarded as a gift of nature to fulfill the basic needs for survival. As most of the water needs are common, water is seen as a common resource over which universality of rights should prevail and every user must have access to water for fulfilling all relevant needs. The water management traditions in rural India are organized within small-scale village communities. While certain needs such as drinking, cooking, washing, cleaning and bathing are common to all, those pertaining to certain productive purposes have traditionally been caste-specific. The land owning agricultural community uses water for irrigation, others like potters, washermen and cattle herders use it for specialized livelihoods.

The rights of access enjoyed by the community members with respect to different water sources are traditionally governed by the beliefs and values associated with different communities. Fulfillment of water needs is accomplished through harnessing of the naturally available water resources. The water resources available within the physical boundaries of the village are regarded as village resources such as *Johad, Poker, Kund, or Talab* in Indian context. While a number of sources may be naturally occurring such as river and lake, others like pond, tank and well are created to harvest the different kinds of water reserves. Their advantage is that local villagers have water related knowledge about their area, which is used in identifying sites and other ground features before creating new water sources.

Water challenges and the management of water resources in Gujarat

Gujarat has just 2.3% of India's water resources and 6.4% of country's geographical area. The State has an average annual rainfall of 80 cm with a high coefficient of variance over time and space and as a result droughts have been frequent. The State has only eight perennial rivers and all of them are located in southern part. Around 80% of the State's surface water resources are concentrated in central and southern Gujarat, whereas the remaining three-quarters of the State have only 20%. On average, three years in a cycle of 10 years have been drought years (Gupta, 2004).

The state government took steps to promote local water systems during mid 1990 through setting up a state level Recharge Committee to promote rainwater harvesting. In the Action Plan for the year 1996-97, the government decided to promote two rainwater harvesting schemes, namely, Roof Water Collection Tankas for households and the scheme of recharging ground water through local rainwater harvesting structures at the community level. In 1998-99 the state government launched Sardar Patel Participatory Sahbhagi Jal Sanchay Yojana (SPPWCP) to promote the ongoing check dam movement in the state, and particularly in Saurashtra, which was a suitable area for check dams, with the rapidly flowing 70 rivers in the region. For drinking water supply, creation of the Water and Sanitation Management Organization (WASMO) was a significant shift in the role of governance from provider to facilitator by empowering village level institutions through extensive capacity building and pro-active facilitation. Since its inception, WASMO has brought about effective citizens' engagement through facilitating successful community led water supply programme throughout the State of Gujarat.

With the increasing water crisis in the state, the government moved more and more towards crisis management. The increased frequency and intensity of droughts, which were accompanied by shortages of drinking water, pushed the state to look for quick solutions to the problem. The major components of the crisis management included fixing new pipelines for Regional Water Supply Scheme to reach problem areas, lifting Narmada water to feed new and old drying pipelines, feeding new and old pipelines (where sources have dried up) by drilling emergency bores and tube wells. Transferring water to problem areas by water tankers, water trains and even ships and drilling bores, tube wells etc to access water from deeper aquifers for local population were also resorted to whenever possible.

Community based water storage structures

Despite several governmental measures, a number of other alternative mechanisms of water collection, storage and management have been in use for a long time. A particularly strong engagement has been the traditional water harvesting systems (Appendix). Apart from being devised in consonance with the local environment (including, hydrology and topography) and socio-cultural specificities, these systems have helped recharge groundwater, fulfilled local demand for the resource. These sources are also used for irrigating the cultivated land. About 23% of the Indian households use water resources like tank, wells and tube wells owned by village panchayat or a community of the village or those provided by the government and government canals, rivers and springs, for irrigating their land (NSSO, 1999).

Figure 1. Location of the study.

As most of these traditional water sources are in the hydrological and socio-cultural domain of rural areas, these are best managed by the local communities. These community based water storage structures, however, have not been able to serve these purposes efficiently for the reasons such as neglect emphasis on alternate source (Das, 2005) and construction far from the settlement (Hirway, 2005). Considering the importance of these CBWS, the present study was taken up to understand the social and technical issues in the management of CBWS and interplay of these factors to draw policy implications.

The paper is organized in the following manner. The methodology followed in designing survey instruments, data collection and model used is given in Section 2. Section 3 describes the results of the study. In section 4, the implications of the results to the study area in particular and other region in general are discussed. The final section provides the concluding remarks.

MATERIAL AND METHODS

The potential of fresh water availability in Gujarat reveals its intensity to be on higher side in Saurashtra, Kutch and north Gujarat (Patel, 2007). The water storage potential, therefore, is high in this region. The study was, therefore, confined to the north Gujarat region and Dhanduka Taluka of Ahmedabad district was selected (Figure 1) based on number of structures. Total geographical area of the district is about 7.7 lakhs hectares, out of which 65.3% of the geographical is under cultivation. About 32% of the cultivated land is irrigated, half of which is irrigated by tube wells.

Table 1. Locations and number of community based water storage structures chosen for survey.

S. No.	District and taluka	Village selected	Community based water storage structures
1	Ahmedabad, Dhanduka	13.	22

Survey instruments

Extensive primary surveys and focus group discussions at the household levels formed the empirical core of this study. Socio-economic data were elicited through structured questionnaires prepared and finalized after pre – testing. Hydro geological and engineering enquiries were also envisaged, apart from the socio-economic surveys, as an integral component of the study. The hydro geological data gathered through field trips (and supplemented by secondary information) were useful in establishing the potential sustainability of the individual systems.

The entire survey exercise involved (i) finalization of the sample sites and the systems; (ii) collection of basic village level information including community owned ponds; (iii) household survey covering socio-economic characteristics and pattern of water use; (iv) focus group discussions to elicit villagers views and perceptions about pond related issues. This was followed by geo hydrological and structural surveys of the structures.

Selection of systems and sites

Community talavs (ponds), widely prevalent in these regions, were selected after discussions with different stakeholders, including concerned government and NGO officials. Details of the survey locations and systems are given in Table 1.

Sampling of households

The guiding factor in the selection of households was the fact that the households were using the selected ponds. The proportion of sample households selected from each village varied depending on the number of households using the pond water in a particular village. The sample size was influenced by the factors viz., topography, distance between the pond and the houses.

Survey instruments

Elaborate survey instruments were prepared for the purpose of collection of both quantitative and qualitative data from the primary source. The survey was carried out to collect information through (i) village level and household level survey instruments and (ii) geo-hydrological and engineering survey instrument.

Village level questionnaire

This had two parts. Part A was used to collect information on area, broad socio-economic characteristics of village population, access to public utilities and basic amenities. Part B was meant for eliciting detailed information on existence of public and private sources of water supply, groundwater levels, irrigation sources, and other relevant water related issues.

Household level questionnaire

This survey schedule had been designed to collect household level information on demographic profile of the family, social status, occupation, sources of income, housing details, land holding and also variety of information on domestic water collection and use.

Geohydrological and engineering survey questionnaire

The schedule was used to collect information on location, design, hydro-climatic data and catchment characteristics of the structures. The triangulation approach was followed to cross-examine responses to ensure similar result to a question with different methods (Denzin, 1978) to ascertain reliability of data collected.

Conceptual framework

Management of community based water storage structures

Oakerson’s model (Oakerson, 1986) was used to understand the management issues of the community based water storage structures. The model gives a framework which can be used to examine the management issues and establish the relationship among the attributes. The model was used to examine four components viz., (1) technical/ physical attributes of the ponds; (2) the decision making arrangement in terms of organizations and rules governing the water users; (3) the patterns of interaction among decision makers and (4) outcomes and consequences (Figure 2). It was hypothesized that the technical and physical factors affect the functionality of the ponds. A functional pond which delivers water on regular basis would be financially viable by providing different services and would be better maintained. An efficient and regular delivery of water would encourage the local stakeholders to create viable institution for management. It is hypothesized that a financially viable functional pond would encourage collective action and strengthen the institution created for that purpose.

Factors affecting resource management

A successful community based water storage structure is one that is able to reliably deliver services to the target community, through physical and financial support from the community, with little intervention from external sources. This has been examined as factor of two components, viz., financial viability of the structures and functionality of the structure (Figure 3). The finances generated from pond water use would sustain the structure through regular maintenance, thereby, improving efficiency of the water delivery system, while a functional pond would ensure reliable service on sustainable basis. To examine financial viability of the ponds, a Financial Viability Index (FVI) was computed in terms of charges collected for domestic water use, charges collected for livestock water use, frequency of collection, utilization of collected saving (pond maintenance), mode of water charge collection. This was hypothesized to be affected by household characteristics such as perception about change in water collection time, Panchayati Raj Institutions (PRI) functionality and number of household drawing water from resource and population below poverty line. FVI was

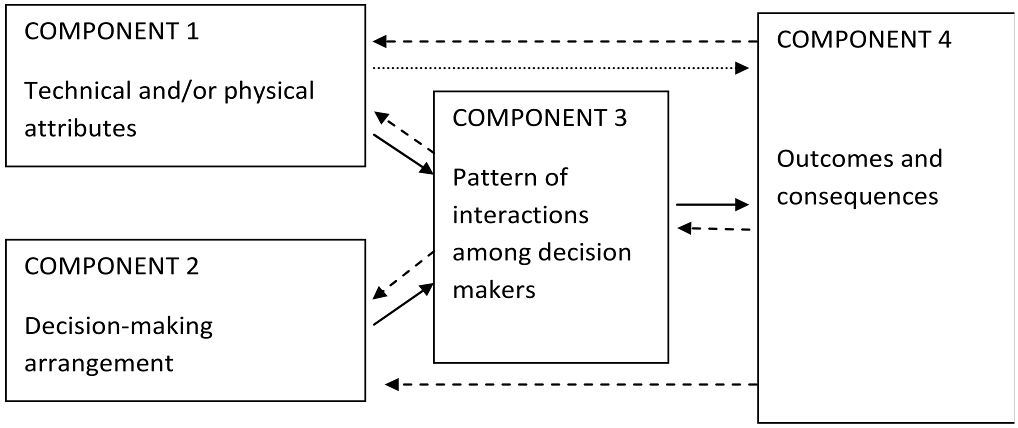

Figure 2. A diagrammatic representation of the Oakerson (1986) model. Solid lines depict basic relationship, broken lines depict relationship in long run.

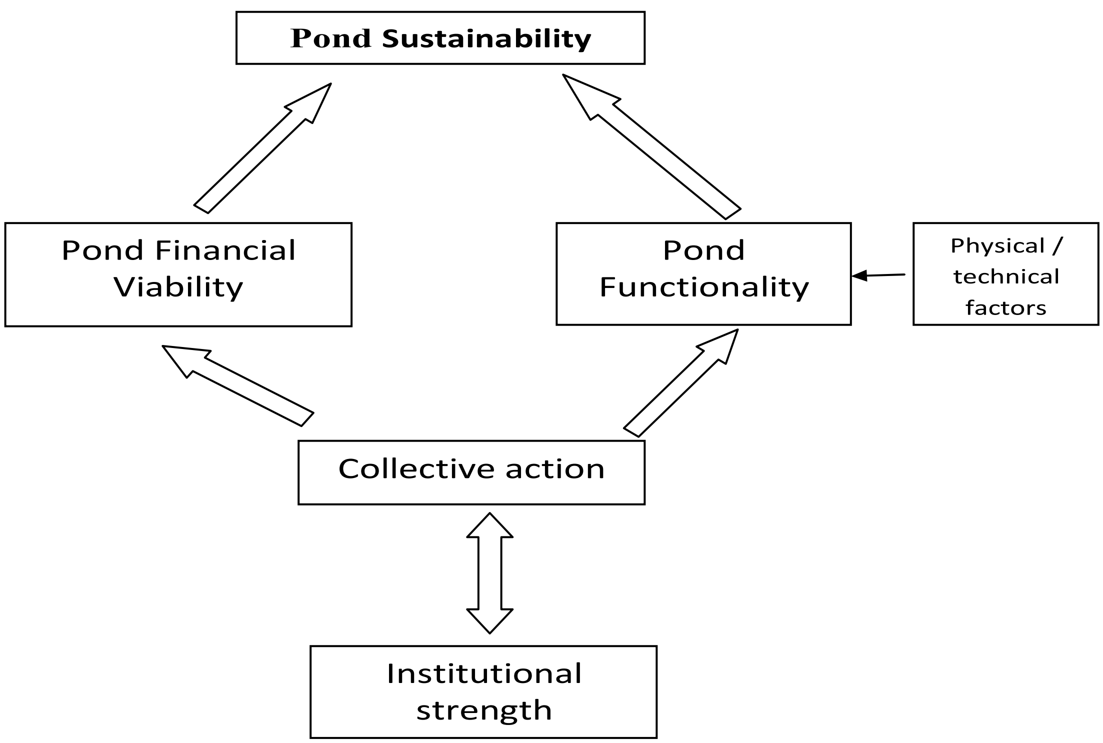

Figure 3. Framework adopted for study of local governance.

regressed on these factors to understand their relationship. Pond functionality was measured in terms of operationality (number of days the structure has water in a year) and pond status. Factors affecting the operationality included the physical and technical design factor associated with the pond. Pond status was examined in terms of perception of beneficiaries about the status of community pond. This was verified with physical surveys in the field. The factors affecting this included distance of pond from the settlement, accessibility and the water use restriction. Panchayati Raj Institutions' functionality in pond management was measured in terms of meeting and participation in decision making, amenability/ capability to resolve water management issues, social representation in the PRI executive body (resolving social conflict) and benefits perceived from community water source.

For the study, data collected from field surveys during 2009-10 and 2010-11 in a study in Gujarat were used to examine this framework in order to draw policy implications. Twenty two ponds selected randomly were studied extensively to understand these factors. Personal interviews of 90 beneficiaries and members of Panchayati Raj Institution, an elected body for managing the selected ponds, were conducted through structured questionnaires.

Model used

While technical and physical attributes and the various factors affecting it were examined by fitting pond operationality and pond status perception relationships, the financial viability was examined by fitting a relationship between financial viability index and the independent factors affecting it. Logit and regression models were fitted to establish various relationships.

Pond operational functionality relationship

$Y = f(X_1, X_2, X_3, X_4)$ (1)

Dependent variable

Y = Operational functionality of pond (water stored during the year)

Dichotomous variable, more than six month = 1, otherwise 0

Independent variable

X_1 = Catchment Land use (Non-arable land = 1, Arable land = 0)
X_2 = Surplus arrangement (Separate inlet and outlet = 1, otherwise=0)
X_3 = Storage to catchment ratio (More than 0.1 = 1, otherwise = 0)
X_4 = Pond seepage behavior (No seepage = 1, otherwise = 0)

A logit model was fitted for understanding the relationship between operational functionality of the pond and the factors affecting it. The non-arable land, which in case of these ponds is mostly open land with little scrubs, was hypothesized to produce more run off into the ponds and positively sustain the operationality of the pond. So a pond with non-arable catchment land was hypothesized to be positively related to operational functionality. Ponds with separate inlet and outlet systems were observed to retain water for longer time and, therefore, such ponds were hypothesized to be positively related with ponds' operationality. Studies have shown that if rainfall runoff was to be used, and stored in a reservoir to supply the ponds, a ratio of 10 ha of catchment area to 1 ha of pond was required if the catchment area was pasture; a slightly higher ratio was needed for woodland, and less for land under cultivation (Kovari, 1984). It was, therefore, hypothesized that storage to catchment ratio of more than 0.1 would suitably keep the pond operational. Similarly, a pond with no seepage would retain water for longer time. Pond with no seepage was hypothesized to have positive relation with operationality of the pond.

Pond functionality perception relationship
$Y = f(X_1, X_2, X_3)$ (2)

Dependent variable

Y = Pond status (Perception of beneficiaries about present status, good = 1, otherwise 0)

Independent variable

X_1 = Distance from village (Less than one kilometer = 1, otherwise = 0)
X_2 = Accessibility to resource (Unrestricted to all = 1, otherwise=0)
X_3 = Water use restriction (All uses (domestic, animal, irrigation) = 1, otherwise = 0)

A logit model with pond status perception as dependent variable was fitted with relevant independent variables. It was hypothesized that pond status perception affects beneficiaries' involvement with the management issues of the community owned water storage structures (Tyson, 2011). A positive perception motivates to participate in pond management. This was regressed over factors such as pond distance from village, pond accessibility and water use restriction. It was hypothesized that resource with less distance, unrestricted use and within village premises would receive better involvement of the beneficiaries and would have good status. Ponds within village premises were better looked after and were, therefore, perceived to have good status. A pond outside the village premises but less than one kilometer was hypothesized to affect people's perception positively. This draws from the concept of 'no source village' to identify villages with inadequate water supply. This concept was introduced in the Fourth Five Year Plan of the state, wherein, one of the conditions, for a village to be no source village, was the source of water supply being more than one kilometer away (Hirway, 2005). It was hypothesized that a pond less than one kilometer from the village would be perceived with good status positively as beneficiaries would draw the benefits with ease. Similarly, ponds with accessibility to all beneficiaries were hypothesized to have good status. Ponds with all domestic and irrigation uses were perceived to have good status, in the same manner.

Financial viability relationship
$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7)$ (3)

Dependent variable

Y = Financial viability Index

Independent variable

X_1 = PRI functionality index (Panchayati Raj Institutions functionality in water resource management)
X_2 = Perception about change in water collection time since constructing the pond (Positive change = 1, no change = 0)
X_3 = Number of household dependent on pond (Nos.)
X_4 = Number of BPL household dependent on pond (Nos.)
X_5 = Total benefits accrued from the pond (Rs.)
X_6 = Private water source owned by the members of PRI body (Yes =1, No=0)
X_7 = Perception about change in water quality (Yes = 1, No = 0)

A pond was hypothesized to be financially viable if more fee is collected on regular basis and is utilized with unanimous decisions of the members of the PRI on pond management. It was hypothesized that a functional PRI would positively manage the members to contribute to the finances for the maintenance and up keep of the pond (Kumar and Vashist, 2005). PRI functionality was computed from factors, viz., meeting and participation in decision making, amenability to resolve water management issues, social and gender representation in PRI decision making body and benefits perceived by members and non-members of the body assigning equal weightage to each of them. A positive perception about change brought about by the pond would induce the beneficiaries to contribute to the finances. In the same manner, while higher number of beneficiary is positively related to financial viability of the community structure, the effect of a higher number of beneficiary household below poverty line would be contrary to that. Further, it was hypothesized that with higher benefits accruing from the pond, fee charged for water use would be higher, as more

Table 2. Village profile of selected water storage structures.

Village name	Geographical area (ha)	Agricultural land(ha)	Irrigated land (ha)
Rayka	1569	1382	114
Khadol	1204	1200	500
Khasta	1600	1584	16
Haripura	880	880	40
Fatepur	1120	1104	-
Jaska	2400	1600	83
Vagad	799	763	480
Pachcham	4238	3325	60
Gunjar	1000	800	280
Pipli	7500	6667	167
Bahadi	50	50	-
Tagadi	583	583	-
Zinkhar	1000	917	167
Morasiya	900	600	33

beneficiaries would be willing to pay, as compared to those structures with lower benefits. A PRI with members owing their private water resources would not be much concerned about its maintenance, thereby, affecting the finances collected for the community structure. The perception about change in water quality available from the community structure would, similarly, play a role in beneficiaries' decision about contribution to finances for that pond.

RESULTS

Although the community ponds' construction is the responsibility of government, a majority of these are managed as common property resource under the supervision of gram panchayat. Two types of ponds are in existence viz., village pond and farm pond (*Sim Talav*). Village pond serves the domestic purpose of cloth washing, utensil washing including animal drinking and hygiene purposes. Some village ponds with large storage capacity also supply water for supplementary irrigations, though such ponds were in minority. The domestic use in most of the villages is supplemented by alternate sources such as Narmada canal and private tube wells. The farm pond serves the purpose of irrigation and animal drinking.

Village profile

The twenty two community based water storage structures selected for extensive study are distributed over thirteen villages (Table 1), the geographical size varying from 50 to 7500 ha. The villages are largely (80% villages surveyed) dominated by weaker sections of society. Only 40% of them have a primary health centre. Except one village, others do not have any banking facility. However, the credit needs are looked after by cooperative societies in majority of the villages. The share of agricultural land in total geographical area is quite high (varying between 70 to 90%) but irrigated land is very small (Table 2). Most of the cultivation being rainfed, the water storage structures largely meet the domestic and animal water requirements, though in some villages these also serve the supplementary irrigation requirements.

Technical and physical attributes of pond

The technical and physical constraints can be analyzed against three concepts drawn from economic literature, (1) jointness of consumption and supply (2) exclusion, and (3) indivisibility (Oakerson, 1986). The relevant conditions are the factors that govern the pond water demand and supply. The boundary of the pond water demand is defined on the physical side by soil, hydrology and the construction of the pond. The pond command area is down side and at a distance from the pond. On the supply side, the resource is defined by the capacity of the pond and the source (catchment) of the pond water (Table 3). The capacity of water distribution pipe and its maintenance decides distribution of water during the peak irrigation times. Some ponds frequently suffer water shortages and water use for all purposes, viz., domestic, animal and irrigation use is a problem. While jointness is not a problem in the use of pond water *per se*, irrigation pipe laid for supplementary irrigation is a limitation in water use by a group of beneficiaries. The maintenance of pipe line for irrigation is a problem as the responsibility of its maintenance is not properly agreed upon and enforced.

Since, the rights to water in the pond can be subdivided, the indivisibility aspect does not necessarily pose

Table 3. Technical and physical attributes of village ponds.

Pond No	Pond name	Surface area (m^2)	Depth at mid point (m)	Shape	Catchment area (ha)*	Major catchment Land use
1	Pipli	56121	2.0	Irregular	530.0	Non-arable
2	Zinkhar	360000	3.0	Irregular	400.0	Non-arable
3	Tagadi	450000	3.0	Irregular	600.0	Non-arable
4	Bahadi	78000	3.0	Irregular	200.0	Non-arable
5	Jaska talav 1	257300	6.0	Irregular	600.0	Non-arable
6	Jaska talav 2	50000	2.0	Irregular	40.0	Non-arable
7	Khasta talav 1	10000	3.0	Rectangular	15.0	Arable
8	Khasta talav 2	12500	2.0	Rectangular	24.0	Arable
9	Khasta talav 3	114100	4.0	Irregular	530.0	Non-arable
10	Panccham talav 1	233628	2.5	Rectangular	25.0	Arable
11	Panccham talav 2	200000	6.0	Irregular	600.0	Non-arable
12	Fatehpur	77700	3.0	Irregular	600.0	Non-arable
13	Haripur	41490	5.0	Irregular	300.0	Non-arable
14	Khadol	305100	4.0	Irregular	500.0	Non-arable
15	Rayaka talav 1	5625	3.0	Rectangular	7.0	Arable
16	Rayaka talav 2	8590	4.0	Irregular	150.0	Arable
17	Rayaka talav 3	30000	3.0	Irregular	200.0	Arable
18	Morasiya	14653	3.0	Irregular	200.0	Arable
19	Vagad talav 1	9000	2.5	Rectangular	100.0	Arable
20	Vagad talav 2	6375	2.5	Rectangular	50.0	Arable
21	Vagad talav 3	6715	2.0	Rectangular	17.0	Arable
22	Gunjar	24399	2.0	Irregular	150.0	Arable

*Approximation through observation and discussion with villagers

any problem for their management once the pond investment is made. Each villager is eligible to draw water from village pond for any domestic use as per the requirement. The water supply is usually enough to serve the intended purpose; though in some ponds it remains scarce during the summer season. Further, the supply is limited by the pond's storage capacity and the quantity of water available to fill the tank, which is dependent on catchment characteristics. Some ponds retain water for the major part of the year during normal rainfall, while others become dry in five to six months. Similarly some ponds (60% of the sample surveyed) are filled more than once a year while others are filled only once in a year. Some ponds (22%) also have water over flow during the season. Siltation and seepage problems (41%) have reduced the storage capacity of many ponds. The surplus arrangement (inlet and outlets) in the pond also affects the amount of water stored and thus, its availability to the beneficiaries. Though majority of the ponds (86%) have proper inlet and outlets, others either have breached or in defective condition. Absence of maintenance has reduced the water storage capacity of the ponds.

About 59% ponds have tube wells in their command and benefit from groundwater recharge. The farm ponds (*Sim Talav*) are not only used for irrigation but also help recharge the wells. The rise in their water table is reported in the range of 1 to 3 m as a result of pond water during post monsoon season period. The area irrigated varies from 2 ha in case of small pond to 500 ha in case of bigger ponds. The Narmada canal provides water to some of the villages, as a result, the farmers dependency on village ponds for drinking and cooking use has reduced in majority of the villages.

Decision making arrangements

The decision making arrangements and rules result mainly from the nature of technical and physical constraints and the goal of the water users about their share of water from pond. The conditions for collective use arise when the scarcity of pond water forces farmers to compete for their share of water. Ponds, which are the responsibility of village panchayat, suffered from poor management. However, the panchayat did not meet regularly to discuss water management issues. The meetings to discuss the water management issues were held either once or no meeting held in majority of the cases (90%). In half of the ponds studied, most of the members of management body were aware of the rules regulating pond water use but did not meet to discuss as they had little interest. The members of panchayat could propose a change in rules in only 35% ponds studied, in the remaining management bodies only executive body members could do the same. Majority of the panchayat bodies either had less than 30% women or without a woman member. The problem identified included poor representation of weaker section of community and lack of gender representation in the management body. Only few of the panchayat bodies had small and marginal farmers as members. These two groups largely depended on community ponds for water uses but had poor say in pond management.

Operational rules

The operating rules in case of village ponds pertain to domestic and animal use of the pond water, and avoiding the irrigation use in most cases. Only some village ponds (18%) where the pond storage capacity and catchment characteristics are favourable and water remains throughout the year in sufficient quantity, limited irrigation is permitted through pipe lines. In the majority of the remaining village ponds, water was not allowed for irrigation use.

PRI members were aware of pond management rules in only 35% ponds studied. More than half PRI members were aware of the rules in only 20% cases. In the remaining cases, either less than 25% members were aware or none. Apart from PRI members' awareness about rules, the strength of democratic process in bringing about modification in rules governs the health of the PRI. In only 35% of PRIs, any member of general body could propose the change; in the remaining PRIs only executive body members could propose change/ modification. However, in none of these PRIs had any change been proposed so far. The members of general body could unanimously effect the proposed change in 40% cases. In 25% of PRIs, the change could be effected unanimously by executive member through voting; in remaining cases, it could be done through voting by members of general body.

The rules for pond water distribution did not exist in cases where the pond water supply was in excess of the demand of water from the pond. In addition, in the majority of the cases the executive body of the institution comprises more number of the medium and large farmers with own water sources.

External arrangements

Only a few ponds (less than 10%) are managed by a state department. Other ponds, managed by panchayats, do not have sufficient funds for maintenance. The fee collected for use of pond water is very nominal. The fee is decided by the government, where panchayat does not have any jurisdiction. There is a provision of state assistance in the maintenance of ponds. State department such as Gujarat State Land Development Corporation (GSLDC) has a scheme of desilting of pond in 10 districts of the state. Government provides 90% subsidy; the other 10% is contributed by beneficiary gram panchayat. All villages of these districts within the watershed submit applications along with Gram Panchayat (PRI) resolution. However, the ineffective PRIs in some villages could not avail the benefits of the scheme. As a result, these ponds have silted up reducing the storage capacity.

Patterns of interaction

In majority of the cases (55% PRIs examined), the executive body did not hold meetings to discuss water related issues. Gender discrimination in PRIs was identified as one of the reasons. Women, who mostly bore the burden of arranging water for domestic and animal use, were not well represented in the panchayat executive body. Among the members of executive body, women were members in only a minority of cases (45%). In these bodies, women as sarpanch, head of the executive body, were observed in only a few cases (15%). The other members did not bother to take up the issues related to water from pond. Similarly, in the majority of the cases, executive body members of PRI largely had their own private source or government source like Narmada canal. Hence, no set pattern of interaction was observed related to pond water issues.

Outcome

Ponds with high demand for water against poor supply lead to water conflict in terms of use for irrigation apart from domestic and animal uses. The conflict management in some villages was governed by the strength of the institutions (Table 4). De-silting of ponds, maintaining the earthen bank of the ponds and cleaning of ponds turned out to be the major responsibilities of the executive body in majority of the cases. however, financial constraint was reported to be the problem by 43% PRI at the time of survey. This, along with the technical and physical constraints, affected the maintenance of the ponds (Table 5). Further, the capacity utilization of the ponds reveals inefficiency in water use as there is either under or over utilization (Figure 4). The distribution of benefits (Figure 5) from water use was same across farmers of different land category. This might be due to use of water for, by and large, domestic and animal use in most of the ponds.

Table 4. Pond management in relation to population and water supply in selected ponds.

S. No.	Village name	Village population	Animal Population	Pond storage volume (m^3)	Pond water usage	Social conflict management
1	Pipli	760	750	100200	Domestic, animal, irrigation	Good
2	Zinkhar	823	1520	240000	Domestic, animal	Poor
3	Tagadi	336	106	450000	Domestic, animal	Good
4	Bahadi	45	23	52000	Domestic, animal	Poor
5	Jaska	384	487	1029200	Domestic, animal, irrigation	Good
6	Khasta	3885	382	55000	Domestic, animal	Poor
7	Panccham	2250	1270	349200	Domestic, animal	Poor
8	Fatehpur	574	180	225000	Domestic, animal	Good
9	Haripur	282	50	207460	Domestic, animal	Good
10	Khadol	747	445	1220400	Domestic, animal, irrigation	Good
11	Rayaka	784	193	124360	Domestic, animal, irrigation	Good
12	Morasiya	750	150	49590	Domestic, irrigation	No conflict
13	Vagad	2100	1119	46015	Domestic, animal	No conflict
14	Gunjar	12590	913	58000	Domestic, animal	No conflict

Domestic use includes cloth washing.

Only a few ponds supplied water for agricultural use. The domestic water use is washing clothes and utensils in homes of mostly poor and small farmers; the big farmers managed to purchase water through tankers. People in a few villages drew water from these ponds for drinking use also. These were the villages where farmers were mostly poor who could not afford to purchase water and the Narmada canal pipe lines for supply of water has not yet reached. Hence, in terms of domestic and animal uses there is equity in accessibility to water.

Logit and regression analysis results

The general description of the variables used in the study is given in Table 6. Based on the technical and social attributes, the variables for which consistent data could be procured from beneficiaries were used for analysis and the results of analysis are given in Table 7.

Catchment land use was same in case of all the community structures and the model fitted with this variable turned out to be poor. Factors viz., surplus arrangement in the pond, storage to catchment ratio and pond seepage behavior with operational status were retained for examining the relationship. The fitted model slightly improved with these variables in the final analysis. Storage to catchment ratio turned out to be significantly affecting operation of ponds (11% significance level). The other two factors turned out to be insignificant.

The perception about current status of pond was found to be affected by factors like accessibility to the pond, distance of pond from settlement and water use restriction. These factors significantly affected the current status of the resource at 7, 10 and 2% level of significance, respectively.

Examination of relationship of financial viability index with explanatory variables revealed that PRI functionality, gross benefit from pond and perception about water quality change were significantly related with dependent variable at 8, 20 and 20% significance level, respectively. Perception about change in water collection time was closely related with location of the source from village. Resources closer to village periphery changed in water collection time and affected financial resource of the PRI positively.

DISCUSSION

There is poor representation of weaker section of community and unequal gender representation in the management body. Only few of the panchayat bodies had small and marginal farmers as the member. These two groups largely depended on community pond for water uses but had poor say in pond management. While these partly explained poor governance, technical/ physical and financial factors explained poor perception about resource management and usufruct delivery, which affected their motivation for participation in resource management.

PRI functionality, perception about change in water collection time and number of households served by the pond were responsible for financial viability of the ponds. Perception about change in water collection time was closely related with location of the source from village. Resources closer to village periphery did perceive change

Table 5. Pond performance and the level of management.

Pond name	Physical/ technical constraint	Maintenance agency	Decision making arrangement	Pattern of interaction	Pond performance (water availability in a year)
Pipli	Leakage, siltation	Panchayati Raj Institution	Voting in general body	Once in month	Six month
Zinkhar	Minor siltation	Panchayati Raj Institution	Unanimously by executive body	Nil	Nine month
Tagadi	Siltation	Panchayati Raj Institution	Unanimously by executive body	Nil	Ten month
Bahadi	Minor siltation	Panchayati Raj Institution	Unanimously by executive body	Nil	Nine month
Jaska talav 1	Leakage, siltation	Panchayati Raj Institution	Unanimously by general body	Nil	Ten month
Jaska talav 2	Bund breach, minor siltation	Panchayati Raj Institution	Unanimously by general body	Nil	Nine month
Khasta talav 1	Leakage, minor siltation	Panchayati Raj Institution	Unanimously by general body	Nil	Eight month
Khasta talav 2	Leakage, minor siltation	Panchayati Raj Institution	Unanimously by general body	Nil	Nine month
Khasta talav 3	Siltation	Panchayati Raj Institution	Unanimously by general body	Nil	Ten Month
Paccham talav 1	Leakage, minor siltation	Panchayati Raj Institution	Unanimously by executive body	Nil	Ten Month
Paccham talav 2	Minor siltation	Panchayati Raj Institution	Unanimously by executive body	Nil	Ten Month
Fatehpur	Minor leakage and siltation	Panchayati Raj Institution	Unanimously by general body	Once in month	Nine month
Haripur	Minor leakage and siltation	Panchayati Raj Institution	Unanimously by general body	Nil	Nine month
Khadol	Minor leakage, siltation	Panchayati Raj Institution	Unanimously by general body	Twice a month	Ten month
Rayaka talav 1	Minor siltation	Panchayati Raj Institution	Unanimously by general body	Nil	Nine month
Rayaka talav 2	Minor siltation	Panchayati Raj Institution	Unanimously by general body	Nil	Nine month
Rayaka talav 3	Siltation	Panchayati Raj Institution	Unanimously by general body	Nil	Eight month
Morasiya	Minor siltation	Panchayati Raj Institution	Voting in general body	Once in month	Seven month
Vagad talav 1	Minor siltation	Panchayati Raj Institution	Unanimously by general body	Nil	Eleven month
Vagad talav 2	Minor siltation	Panchayati Raj Institution	Unanimously by general body	Nil	Nine month
Vagad talav 3	Minor siltation	Panchayati Raj Institution	Unanimously by general body	Nil	Nine month
Gunjar	Minor siltation	Panchayati Raj Institution	Voting in general body	Nil	Eleven month

in water collection time, quality and regularly paid for water charges. PRI functioned with poor representation of weaker section of the community and were observed to have poor gender sensitivity. The number of members in the executive body of panchayat varied from 7 to 10, women being member of the body in only 15% PRIs. Similarly, women as sarpanch, head of the body, were observed in only a few cases, and these bodies incidentally held executive body meeting at least once in a year. In other cases, the other executive body did not hold meetings. A multi-country study of community-managed rural water supply systems (Whittington et al., 2009) recognized the importance of women's involvement in water resource management.

Women do most of the work of collecting water in Indian villages as elsewhere in Africa. They must be empowered to manage water related conflicts as observed by Murray (2011) in Democratic Republic of Congo, Afghanistan and Liberia. Representation of weaker section of community also was poor. Except for a couple of cases (10% of PRIs), in other bodies the members were medium and large farmers, and had their own private source of water such as tube wells. They drew least benefits from pond and

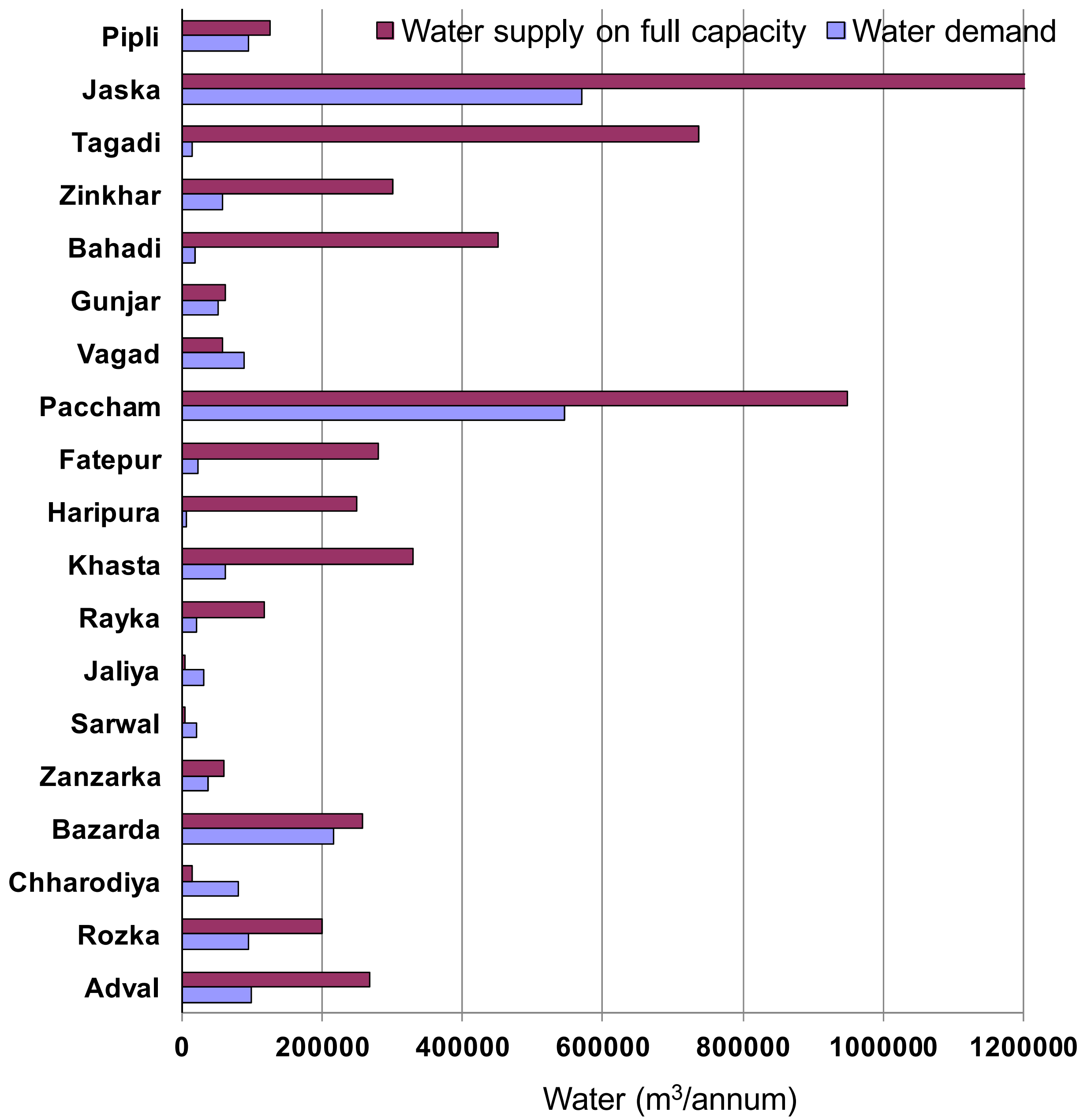

Figure 4. Demand and supply of water in selected ponds

hence, did not bother to take up water issues, in general and pond maintenance, in particular. Paradoxically, the marginal and small farmers fully depended on pond for various water uses but had at least say in their management. PRI functionality can, therefore, be streng-thened by motivating and sensitizing PRI members to water governance issues by enhancing representation of women, who manage water uses at household level and weaker sections of farmers who did not have private water source and, primarily depended on these community resource. The weak sensitivity of PRI towards these community based natural resources can also be partly explained in terms of the network of Narmada Canal and pipeline to villages to meet largely domestic uses as reported elsewhere (Das, 2005). Yet considering their importance in the livelihood of poor and weaker sections, management of community pond must be improved by strengthening the institutions created locally for the purpose.

Accessibility to the resource and use restriction

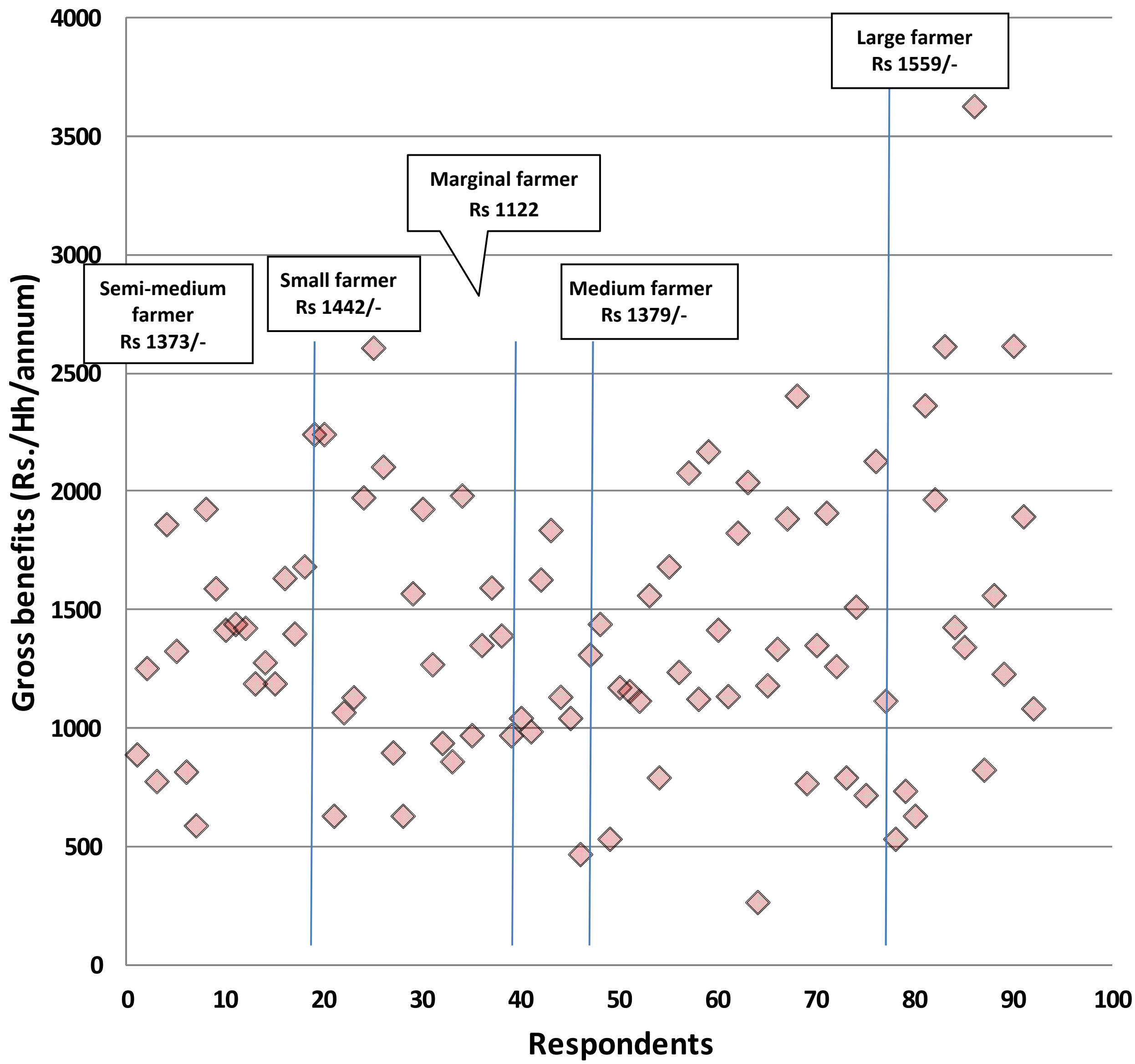

Figure 5. Distribution of benefits drawn from ponds. Note: Land holding categorization; Marginal farmer: Land holding < 1 ha; Small farmer: Land holding 1-2 ha; Semi-medium farmer: Land holding 2-4 ha; Medium farmer: Land holding 4-10 ha; Large farmer: Land holding > 10 ha.

influenced beneficiaries' perception about present status of community based natural resources. Ponds which were accessible to all segments of community were perceived to have served the community in better way as compared to those which were accessible to a few. Such ponds were considered with good status and positively influenced people to contribute financially and physically for their maintenance. Similarly, few ponds had un-restricted use for domestic, livestock and agricultural purposes and these ponds had least conflict in terms of financial contribution. These were the ponds with sufficient water for a longer period of time in the year. Similarly, distance of resource also affected its current status in terms of maintenance. The ponds being located in the outskirt of village, only a few were observed to have easy access. While accessibility to pond in rural community might be rooted in the cosmology of Indian society wherein water sources are socially identified with its user caste (Singh, 2006), use restriction is governed by water storage volume in ponds. Ponds with low storage volume in relation to demand from stakeholders are primarily meant for domestic and livestock use alone. Irrigation use is completely debarred in such ponds. Technical design in terms of size and place of pond

Table 6. Model variables used in the study.

Variable	Description	Mean	Standard deviation	Observations
Pond operational functionality model variables				
Dependent variable				
Operational sustainability Index	Water stored for more than six month	0.77	0.43	22
Explanatory variable				
Catchment Land use	Arable and non-arable land use	0.50	0.51	22
Surplus arrangement	Inlet and outlet system of the pond	0.14	0.35	22
Storage to catchment ratio	Ratio of storage area to catchment area	0.45	0.50	22
Pond seepage behavior	Presence or absence of seepage from pond	0.72	0.45	22
Pond functionality status model variable				
Dependent variable				
CBWS status	Per caption about present status of pond	0.67	0.47	22
Explanatory variable				
Distance from village	Distance of pond from village	0.44	0.50	22
Accessibility	Resource accessibility to users	0.23	0.49	22
Use restriction	Restriction in the use of water from pond	0.52	0.50	22
Financial viability model variables				
Dependent variable				
Financial viability Index	Revenue generation through collection of water charges	1.11	0.17	22
Explanatory variable				
PRI functionality index	Panchayati Raj Institutions functionality in water resource management	1.09	0.32	22
Collection time change perception	Perception about change in water collection time from water source	0.70	0.47	22
Household dependent on resource	No. of household dependent on water resource	463	575	22
BPL household	No. of household below poverty line dependent on resource	133	146	22
Gross benefits	Total benefits accrued from the pond	500498	6.57	22
Private water source	Private water source owned by the members of PRI body	0.70	0.47	22
Water quality change	Perception about change in water quality	0.30	0.47	22

Table 7. Logit model result for community based water storage structures.

Variable	Coefficient	Significance level
Dependent variable : Operational sustainability of pond		
Surplus arrangement	-0.44	*
Storage to catchment ratio	2.08	11%
Pond seepage behaviour	-0.97	*
Number of observations	22	
-2 Log likelihood	9.85	
Pseudo R-Sq. (Cox & Snell R –Sq)	0.16	
Pseudo R-Sq. (Nagelkerke R –Sq)	0.24	
Dependent variable : Pond status perception		
Distance from village	-2.20	10%
Accessibility	2.29	7%
Use restrictions	-3.13	2%
Number of observations	22	
-2 Log likelihood	47.60	
Pseudo R-Sq. (Cox & Snell R –Sq)	0.24	
Pseudo R-Sq. (Nagelkerke R –Sq)	0.34	
Dependent variable : Financial viability		
PRI functionality index	6.63	8%
Collection time change perception	23.5	*
Household dependent on resource	0.001	*
BPL household	0.007	*
Gross benefit from pond	0.00002	20%
Private water source	-0.70	*
Water quality change	-2.58	20%
Number of observations	22	
-2 Log likelihood	19.82	
Pseudo R-Sq. (Cox & Snell R –Sq)	0.51	
Pseudo R-Sq. (Nagelkerke R –Sq)	0.63	

* Insignificant.

construction partly explained this. Incidentally, storage to catchment ratio turned out to be one of the factors affecting operationality of the pond. The technical design and planning of the pond in relation to catchment characteristics and size (Kumar and Vashist, 2005) in the vicinity of the village settlement might not only affect the services provided by the resource but also overcome use restrictions. This would positively induce the local stakeholders in regular management of the resource. Further, a pro-poor strategy such as organizing the economically weaker farmers into user groups to harness water based non-agricultural benefits like fish cultivation could help bring them into mainstream of social empowerment.

CONCLUSION AND POLICY PRESCRIPTION

The active participation and local governance of community resources for more efficient, effective and equitable development need promotion of equitable participation of women and weaker section of rural community. The essential assumption here is that women and poor farmer represent a marginalized group in society whose lives are entrapped in an institutional framework characterized by gross inequalities of formal power and authority in the public sphere and denied equal access to and control over resources (Singh, 2006). Observations around the world suggest that institutional structures with gender-equity based participatory models of local governance would balance out the inequalities by offering a platform or space where women (Aladuwaka and Momsen, 2010) and weaker sections of society (Barnaud et al., 2010) could come together and be empowered to express their opinions as well as contribute effectively in decision-making processes. With respect to the water sector in general, women's participation seeks to correct imbalances perceived in terms of access to water resources and benefits from water development projects as well as exercise of decision-making powers with respect to the management of these resources (UNDP, 2003; GWA, 2003). Strengthened institutions being a panacea for efficient resource management, technical design and scientific planning in creating water resources, nevertheless, would go a long way in serving the rural community efficiently as these factors not only affected the ponds' functionality and financial viability but also people's perception about resource utility and efficiency in service delivery. A storage of catchment ratio of more than 0.1 or more has been suggested appropriate (Kovari, 1984) for pond utility such as aquaculture. Such ponds with water for sufficiently longer period of time would also serve other purposes of rural livelihood.

There is need to create management systems where the formal decision-makers such as PRI interact with relevant members of the scientific community (Kumar and Vashist, 2005; Kurian, 2000), users and other stake-holders for a coordinated approach that successfully orchestrates water uses towards hydro geological and socio-cultural compatibility. Water resources management in the 21st century requires a radical reorientation and an effective dialogue between decision-makers, stakeholders and the scientific water community (Falkenmark et al., 2004).

Conflict of Interests

The author has not declared any conflict of interests.

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Appendix. Typology of traditional water harvesting Systems in Gujarat (adopted from Das, 2002).

Description	Geographical region	Remarks
Tanks		
Constructed *in situ* with massive masonry walls on four sides and almost impermeable floor as a standard pattern. They are either square or rectangular and had an enormous water-holding capacity. Tanks were invariably provided with an efficient system of canals to bring rainwater from the catchment areas and are thus constructed downstream.	All over the Thar region of Gujarat Tanks are the most commonly occurring rainwater harvesting systems.	Tanks in Thar were built for both drinking, and irrigation purposes. But now most of these are now polluted, their catchments encroached in urban areas. Today most of the tanks in Thar are facing extinction.
Talavs		
A *talav* is a popular word used locally for water reservoirs situated in valleys and natural depressions. In old *talavs*, only the slope side was provided with strong parapet walls to hold the rainwater. Other sides were naturally supported by outcrops of hillocks or elevated rocky formations.	All over Gujarat state	These talavs have been the main source of water for the human and animal population until recently. Water from these talabs is still used for drinking and other purposes by the local population. But their catchments are being eroded and destroyed at many places by urban activities. They are also feeding a large number of wells and *baoris.* If the *talabs* go dry, the survival of a large number of wells and *baoris* will be threatened.
Wells		
Well is a shaft sunk into the ground to obtain water/ a water spring or fountain.	Traditionally, wells have been the principal means of water harvesting in Gujarat.	Wells were the most important source of water both for irrigation and drinking water purposes.
Bavdis		
Bavdis or the community step wells are shallower than wells, they have beautiful arches along their full height. Bavdis can hold water for a long time because of almost negligible water evaporation when compared to other water bodies. Step wells were used for various reasons, and their location often suggested the way in which they would be used. When a step well was located within or at the edge of a village, it was mainly utilitarian purposes and as a cool place for social gatherings, usually for drinking purposes for traders, military and travelers.	Step wells are found all over Gujarat but more so in the northern and central parts. In Kutch only a few step wells are found and they are small and without elaborate carving. Many step wells are found on the routes from Patan in the north to the seacoast of Saurashtra	Bavdis were the only source of drinking water earlier but now these are no more used for drinking water.
Kunds		
In the sandier tracts, the villagers of the Thar Desert had evolved an indigenous system of rainwater harvesting known as kunds or kundis. Kund, the local name given to a covered underground tank, was developed primarily for tackling drinking water problems. Usually constructed with local materials or cement, kunds were more prevalent in the western arid regions of Rajasthan and in areas where the limited groundwater available is moderate to highly saline. The kund consists of a saucer- shaped catchment area with a gentle slope towards the centre where a tank is situated. Openings or inlets for water to go into the tank are usually guarded by a wire mesh to prevent the entry of floating debris, birds and reptiles. The top is usually covered with a lid from where water can be drawn out with a bucket. Kunds are by and large circular in shape, with little variation between the depth and diameter which ranges from 3-3.5 m. The catchment size of the kund varies from about 20 sq. km to 2 ha depending on the runoff needed and the availability of spare land.	There are numerous kunds in Gujarat also, though their number is less than Rajasthan. Kunds were usually found in Northeastern Gujarat.	In Gujarat construction of kunds was for agricultural purposes. Some kunds were even used as tanks for tanning of leather or dyeing of clothes. The catchments of most of the kunds have been destroyed.

Virdas		
In dry riverbeds and lakes, scoop holes are known as virdas in Gujarat. The water in the virdas is usually sweet, being located in the top layers of the sand.	In Banni area of Kutch, and at the edges of Rann	
Jali Karang and Bhandaras		
Bhandaras or Storage tanks which collect groundwater from underground springs flowing down from the Satpura hills towards the Tapti river. The water is carried through subterranean conduits with a number of connected wells to a collection chamber called jali karanj, and from there to the town. The water from jail karanj in mughal times would reach Burhanpur through clay pipes, which were later replaced with iron pipes. At every 20 meter along the entire path of the tunnel from source (bhandaras) to jail karanj air shafts have been provided.	System specifically designed by Mughals based on gravity.	Today people living around these airshafts use them like wells, as water flows through the tunnels throughout the year. The system is still useful but due to sheer negligence may soon become history. The main problems are over the years; pores and openings have got blocked due to the accumulation of the deposits of chemicals, declining groundwater levels, sedimentation of shafts and tunnels.