Physical and Social Factors in Management of Community Based Water Storage Structures in Gujarat: An Institutional Analysis of Local Governance

Pande VC1*, Bagdi GL1 and Sena DR2

1Central Soil and Water Conservation Research and Training Institute, Research Centre, Vasad (Anand), Gujarat, India
2Central Soil and Water Conservation Research and Training Institute, Dehradun, Uttarakhand, India

Abstract

Policy intervention in the management of community based water storage structures (CBWS) depends on identifying the factors governing collective action and institutions. Institutional factors not only have a direct bearing on the functioning of CBWS but also often interact with physical and technical factors to influence their sustainability. The present study has examined these issues taking sustainability of CBWS as a function of two components, financial viability and CBWS functionality to draw policy implications in Indian context. Data collected from field surveys revealed that Panchayati Raj Institution (PRI) functionality, perception about change in water collection time and number of households served by the water resource significantly affected financial viability of CBWS. The CBWS functionality was, similarly, found to be significantly affected by factors like accessibility and use restriction with respect to the CBWS. PRI functionality in respect of community resource management, therefore, need to be addressed 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 affected the physical status of the resource and catchment land use and storage to catchment ratio, which affected operational status of the source, are critical while designing location and size of the water resource such as pond.

Keywords: Community water storage structures; Management; Physical and social factors; Pond

Introduction

Water as common pool resource is indispensable for human life and development. It is efficient, effective, and sustainable use is paramount for ensuring sustainable development. The institutional arrangements for water management are diverse, varying in their structure, scope and style. As a common pool resource, the management of water can be organized under different types of regimes. In open access regime, rules regulating access to and allocation of benefits from the resource are absent. In public property regime, access rights for the public are held in trust by the state. In Private property regime, on the other hand, tradable rights are owned by an individual, household or company. Common property regime (CPR) entails a set of rules to govern access to, allocation of, and control over water [1]. In CPR regimes, some form of organized collective action between the individuals constituting the user community is contemplated; since a collective effort is required to manage access to the CPR and allocation of the benefits it produces [2].

Failures under public and private management have lead to community participation as an alternative mode to govern the resource [3]. In fact, participatory approaches to natural resource management are increasingly being advocated, world over, to promote local stakeholders’ involvement in effective management of resources [4]. The literature on Common Property Resource management has also taken cognizance of this fact [5,6].

Interaction of various factors and, hence, design of policy instruments in respect of community based water storage structures (CBWS), however, is quite complex. This is more so because of poor understanding of the interaction and lack of sufficient empirical insight into identifying factors affecting the interplay of local governance forces [7]. Ineffective institutions and their overlapping mandates are, however, also frequently seen as bottlenecks for sustainable natural resources use, with institutional reforms and increased institutional coordination promoted as a solution [8-10].

Policy intervention in the management of community based water storage structures (CBWS) depends on identifying the factors governing collective action and institutions. Studies have shown that institutional factors not only have a direct bearing on the functioning of tank irrigation but also often interact with physical and technical factors to influence tank sustainability [11]. In the present study, sustainability of CBWS is hypothesized to be a function of two components, financial viability and CBWS functionality. Examination of these factors within the frame work of collective action will develop an understanding of the interplay of various physical, technical and social factors, which in turn, will help strengthen, preserve and enhance the collective action through policy intervention on financial and functional parameters of CBWS. Since local institutions are shaped by collective action, these policy interventions will strengthen the institutions for management of community based water storage structures.

Methodology

Study location and survey instruments

The study was conducted in Dhanduka taluka of Ahmedabad district in Gujarat (Figure 1). The selection of study area was based on number of structures. Total geographical area of the district is about
770,000 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.

The empirical core of this study derives from extensive, primary surveys and focus group discussions at the household levels. Structured questionnaires were prepared and finalized through pre-testing for socio-economic data elicitation. Apart from the socio-economic surveys, relevant hydro geological and engineering enquiries are also envisaged 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 community water storage structure.

The entire survey exercise was conducted in two rounds. The first round involved (i) finalizing the sample sites and the systems; (ii) collecting basic village level information including sources of water; (iii) household survey focusing on socio-economic characteristics and pattern of water use; (iv) focus group discussions to obtain villagers views and perceptions about specific system related issues. The second round included (i) field surveys for geo hydrological and structural features of the structures.

**Selection of systems and sites:** Following discussions with different stakeholders, including concerned government and NGO officials, community talavs (pond) were identified for study. Twenty two ponds were randomly selected for extensive study.

**Sampling of households:** The major emphasis in the selection of households was placed on the fact of their using the selected CBWS. Depending on the number of households using the CBWS in a given village, the proportion of sample households selected from each village

![Figure 1: Location of the study.](image)
varied. Factors such as topography, distance between the CBWS and the houses also influenced the sample size. An attempt was made to select beneficiaries staying at varying distances from structures. Ninety beneficiaries and two members of Panchayati Raj Institution managing each pond were identified for data collection.

Survey instruments: For the purpose of collection of both quantitative and qualitative data from the primary source, elaborate survey instruments were prepared. The survey was carried out in two distinct phases. In Phase I the village and household survey instruments were applied and in phase II detailed geo hydrological and engineering surveys were conducted.

Village level questionnaire: This was used to collect information on area, broad socio-economic characteristics of village population, access to ponds. In addition, information was elicited on existence of traditional and modern sources of water supply, crops grown, irrigation sources, and other relevant water related issues.

Household level questionnaire: This survey schedule was designed to canvass 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.

Geo hydrological and engineering survey questionnaire: The schedule was used to collect information on location, design, hydroclimatic 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 [12]. This approach helped ascertain reliability of data collected even with low data base used in this study.

Conceptual framework

Sustainability of a community based water storage structure depends on its ability to reliably deliver services to the target community, through financial and physical maintenance support from the community, and with as little intervention from external sources as possible. This was hypothesized to be a factor of two components, viz., financial viability of the structures and functionality of the structure (Figure 2). The former would sustain the structure through regular maintenance, thereby, improving efficiency of the water delivery system, while the latter would ensure reliable service in perpetuity.

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. Factors that predict revenue generation for use of CBWS included 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.

CBWS functionality was measured in terms of reliability (number of days the structure has water in a year). Factors affecting the functionality included the physical and technical factor associated with the structure, the quality of pond management, and the number of residents using the pond. Panchayati Raj Institutions functionality in water resource 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. The data collected pertained to the years 2009-10 and 2010-11.

Model used

Logit and regression models were fitted for establishing various relationships. The dependent variable in functional operationality and pond functionality perception are dichotomous in nature, logit model is best suited to examine the relationship. The financial viability model with dependent variable and index has been solved with multiple regression models, which is best to examine such relationships.

Logit model, also known as logistic regression model, is the functional relationship where the dependent variable is a dichotomous variable with probability of an event occurring or not occurring. Since the probability of an event must lie between 0 and 1, it is impractical to model probabilities with linear regression techniques, because the linear regression model allows the dependent variable to take values greater than 1 or less than 0. The logistic regression model is a type of generalized linear model that extends the linear regression model by linking the range of real numbers to the 0-1 range.

In the logistic regression model, the relationship between Z, an unobserved continuous model, and the probability of the event of interest is described by this link function.

\[ \pi_i = \frac{e^{z_i}}{1 + e^{z_i}} = \frac{1}{1 + e^{-z_i}} \]

This can be written as;

\[ z_i = \log\left(\frac{\pi_i}{1 - \pi_i}\right) \]

Where,

\[ \pi_i \] is the probability the \(i\)th case experiencing the event of interest

\[ z_i \] is the value of the unobserved continuous variable for the \(i\)th case

The model also assumes that \(Z\) is linearly related to the predictors (\(X_{ij}\))

\[ Z_i = b_0 + b_1 X_{ij1} + b_2 X_{ij2} + ... + b_p X_{ijp} \]

Where,

\(X_{ij}\) is the \(j\)th predictor for the \(i\)th case, \(j = 1, 2, ..., p\)

\(b_j\) is the \(j\)th coefficient
otherwise=0)

less than one kilometer was hypothesized to affect people’s perception
involvement of the beneficiaries. A pond outside the village premises but
unrestricted use and within village premises would receive better
management. It was hypothesized that resource with less distance,
structures. A positive perception induces to participate in resource
for longer time.

storage to catchment ratio of more than one would suitably keep the
for land under cultivation [13]. It was, therefore, hypothesized that
area is pasture; a slightly higher ratio is needed for woodland, and less
operationality of the pond. Pond with proper inlet and outlet systems
produce more run off into the ponds and would positively sustain the
structures is mostly open land with little scrubs here and there, would
The regression coefficients are estimated through an iterative
maximum likelihood method.

Pond operational functionality model:

Y=f (X1, X2, X3, X4) … (1)

Dependent variable:

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

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

Independent variables:

X1=Catchment Land use (Non-arable land=1, Arable land=0)
X2=Surplus arrangement (Separate inlet and outlet=1, otherwise=0)
X3=Storage to catchment ratio (More than 0.1=1, otherwise=0)
X4=Pond seepage behavior (No seepage=1, otherwise=0)

It is hypothesized that non-arable land, which in case of these
structures is mostly open land with little scrubs here and there, would
produce more run off into the ponds and would positively sustain the
operationality of the pond. Pond with proper inlet and outlet systems
were observed to retain water for longer time. Similarly, if rainfall runoff
is 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 is required if the catchment
area is pasture; a slightly higher ratio is needed for woodland, and less
for land under cultivation [13]. It was, therefore, hypothesized that
storage to catchment ratio of more than one would suitably keep the
pond operational. Similarly, a pond with no seepage would retain water
for longer time.

Pond functionality perception model:

Y=f (X1, X2, X3, X4) … (2)

Dependent variable:

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

Independent variables:

X1=Distance from village (Less than one kilometer=1, otherwise=0)
X2=Accessibility to resource (Unrestricted to all=1, otherwise=0)
X3=Use restriction (All uses (domestic, animal, irrigation)=1, otherwise=0)
X4=Location (With village premises=1, otherwise=0)

Pond functionality perception affects beneficiaries’ involvement
with the management issues of the community owned water storage
structures. A positive perception induces to participate in resource
management. It was hypothesized that resource with less distance,
unrestricted use and within village premises would receive better
involvement of the beneficiaries. 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.

Financial viability model:

Y=f (X1, X2, X3, X4, X5, X6, X7) … (3)

Dependent variable:

Y=Financial viability Index

Independent variable:

X1=PRI functionality index (Panchayati Raj Institutions
functionality in water resource management)
X2=Perception about change in water collection time since
constructing the CBWS (Positive change=1, no change=0)
X3=Number of household dependent on resource (Nos.)
X4=Number of BPL household (Nos.)
X5=Total benefits accrued from the pond (Rs.)
X6=Private water source owned by the members of PRI body (Yes =1, No=0)
X7=Perception about change in water quality (Yes=1, No=0)

An index of CBWS’s financial viability was computed from factors viz.,
fee collected for domestic, animal and irrigation uses, frequency
of collection and mode of utilization. A community structure was
hypothesized to be financially viable if more fees is collected on regular
basis and is utilized with unanimous decisions of the members of
the PRI. It was hypothesized that a functional PRI would positively
contribute to the finances for the maintenance and up keep of the
CBWS. 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 CBWS 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 with higher benefits accruing a
community structure fee charged for water use would be higher 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 and 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 structure.

Result

Village profile

The community based water storage structures selected for study
were distributed over different villages varying in size from 50 ha to
7500 ha (Table 1). The share of agricultural land in total geographical
area was quite high (varying between 70 to 90%) but irrigated land
was very small. Most of the cultivation being rainfed, the water storage
structures largely met the domestic and animal water requirements,
though in some villages these also serve the supplementary irrigation
requirements. The major crops irrigated through supplementary
irrigation include wheat (Triticum aestivum) and cumin (Cuminum cyminum) in winter, fodder sorghum (Sorghum bicolor) in summer and cotton (Gossypium hirsutum) in rainy season (Table 2).

### Technical and physical attributes of the structures

Though each villager was eligible to take water from village pond for any domestic use as per the requirement, the supply was limited by the pond’s storage capacity and the quantity of water available to fill the tank depending upon catchment characteristics (Table 3). Some ponds retained water for the major part of the year during normal rainfall, while others became dry in five to six months. Similarly some ponds (60% of the sample surveyed) were filled more than once in a year while others were filled only once in a year. Some ponds (22%) also overflow during the season. Siltation and seepage problems (41%) had reduced

| Village name | Geographical area (ha) | Agricultural land (ha) | Irrigated land (ha) |
|--------------|------------------------|------------------------|-------------------|
| Rayka        | 1569                   | 1382                   | 114.1             |
| Khadol       | 1204                   | 1200                   | 500.2             |
| Khasta       | 1600                   | 1584                   | 16.5              |
| Haripura     | 880                    | 780                    | 40.7              |
| Fatepur      | 1120                   | 1104                   | 1.3               |
| Jaska        | 2400                   | 1600                   | 83.3              |
| Vagad        | 799                    | 763                    | 480.7             |
| Pachcham     | 42.38                  | 3325                   | 60.2              |
| Gunjar       | 1000                   | 800                    | 280.2             |
| Pipili       | 7500                   | 6667                   | 167.2             |
| Bahadi       | 50                     | 50                     | -                 |
| Tagadi       | 583                    | 583                    | -                 |
| Morasiya     | 900                    | 600                    | 33.2              |
| Zinkharia    | 1000                   | 917                    | 167.2             |

Table 1: Village profile of selected water storage structures.

| Village   | Method of irrigation | Crops and area irrigated | Irrigation | Irrigation depth | Crop yield |
|-----------|----------------------|---------------------------|------------|-----------------|------------|
| Rayka 1   | Lift irrigation through pipe | Wheat 2 3-4 1440 | -          | -               | -          |
| Khasta 2  | Lift irrigation through pipe | Wheat 4 3-4 1200 | -          | -               | -          |
| Pipili    | Lift irrigation through pipe | Wheat 6 3-4 2400 | -          | -               | -          |
| Jaska 1   | Lift irrigation through pipe | Cotton 50 4-5 3000 | -          | -               | -          |
| Jaska 2   | Lift irrigation through pipe | Wheat 10 2-3 1200 | -          | -               | -          |
| Khasta    | Lift irrigation through pipe | Wheat 100 2-3 6000 | -          | -               | -          |
| Rayka 2   | Lift irrigation through pipe | Wheat 50 2-3 1200 | -          | -               | -          |
| Rayka 3   | Lift irrigation through pipe | Wheat 20 2-3 4800 | -          | -               | -          |
| Morasiya  | Lift irrigation through pipe | Cotton 25 4-5 3000 | -          | -               | -          |
| Vagad 1   | Lift irrigation through pipe | Wheat 20 2-3 6000 | -          | -               | -          |
| Vagad 2   | Lift irrigation through pipe | Wheat 4 2-3 6000 | -          | -               | -          |
| Vagad 3   | Lift irrigation through pipe | Wheat 4 2-3 6000 | -          | -               | -          |
| Gunjar    | Lift irrigation through pipe | Wheat 4 2-3 6000 | -          | -               | -          |

Table 2: Details of supplementary irrigation, mode of supply and crops in selected ponds.

*No supplementary irrigation provided from pond
the storage capacity of many ponds. The surplus arrangement (inlet and outlets) in the pond also affected the amount of water stored and thus, its availability to the beneficiaries. Though majority of the ponds (86%) had proper inlet and outlets, the remaining either had breached or were in defective condition. Absence of maintenance had reduced the water storage capacity of the ponds.

**Sociology of community management**

Only few ponds (less than 10% of the ponds) were managed by state department. The remaining ponds were managed by Panchayati Raj Institution (PRI), an elected body for local management. In majority of the cases (55% PRIs surveyed), however, the executive body did not hold meetings to discuss about water related issues. Women, who mostly bear 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 few cases (45% PRIs). In these bodies, women as sarpanch, head of the executive body, was observed in only a few cases (15% PRIs). The other members did not bother to take up the issues related to water from pond. Similarly, in majority of the cases executive body members largely had own private sources. For drinking water, government source like Narmada canal pipe lines were laid in most of the villages. From pond. Similarly, in majority of the cases executive body members largely had own private sources. For drinking water, government

| Pond Number | Pond name   | Surface area (m²) | 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          | Panchcham talav 1 | 233628      | 2.5                    | Rectangular | 25.0               | Arable                  |
| 11          | Panchcham 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*
The results of logit and regression model are given in Table 5. The variables entered and model performance was checked. The final model with best fit was retained. For the pond functionality model, since the catchment land use was same in case of all the community ponds and the model fitted with this variable turned out to be poor, this was dropped in the final fit. The relationship of factors like surplus arrangement in the pond, storage to catchment ratio and pond seepage behaviour with operational status was examined with the response variable and the model slightly improved. Hence, these variables were retained for final analysis. Storage to catchment ratio turned out to be significantly affecting operation of ponds (significance level 11%). The other two factors turned out to be insignificant. The perception about current status of community pond was found to be affected by factors like accessibility to the resource, distance of community water resource from household and use restriction with respect to the resource in the final model. These factors significantly affected the current status of the resource (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**

Pond with high demand for water for domestic, animal and irrigation uses against poor supply experienced water related conflicts (Table 6). The conflict management in some villages, though, was governed by the strength of the institution. While PRI an elected body entrusted with the task of pond management needs to be strengthened, factors such as design and location play important role in influencing beneficiaries’ perception. The accessibility to the resource and use restriction with respect to the resource affected perception about present status of pond. The pond located in the outskirt of village, only a few were observed to have easy access. Storage to catchment ratio affected operationality of the community based water storage structures. Similarly, catchment with arable land use was observed to have water storage for less than 6 months. In those structures with non-arable catchment land use, storage was much higher than that. This catchment was devoid of vegetation except for some scrubs. Though this variable did not appear in the final model but the fact remains that non-arable catchment covered with little scrub contributed to more runoff in the pond in the study area. PRI functionality, perception about change in water collection time and number of households served by the water resource affected financial viability of the ponds. Perception about change in water collection time

### Table 4: 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           |
| 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 perception model variable** |                                                  |          |                    |              |
| Dependent variable            |                                                  |          |                    |              |
| Distance from home            | Distance of pond from home                        | 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           |
| Location                      | Existence within village or outside the village   | 0.27     | 0.45               | 22           |
| **Financial viability model variables** |                                                  |          |                    |              |
| Dependent variable            |                                                  |          |                    |              |
| Financial viability Index     | Revenue generation through collection of water charges | 1.11    | 0.17               | 22           |
| 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           |
was closely related with location of the source from village. Resources closer to village periphery did perceive change in water collection time, quality and regularly paid for water charges. While the change in perception was governed by physical/technical factor in terms of pond size and location, PRI functionality turned out to be an important factor in managing finances for pond management. In fact, PRIs were observed to have poor gender sensitivity. The number of members in the executive body of panchayat varies from 7 to 10, women being member of the body in only few cases (45%). Similarly, women as sarpanch, head of the body, was observed in only a few cases (15%), 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 (55%). Except for a couple of cases (10%), in other bodies the members were medium and large farmers, and having own private source of water.

## Table 5: Logit and regression model result for community based water storage structures.

| S. No. | Variable                              | Coefficient | Significance level |
|-------|---------------------------------------|-------------|--------------------|
|       | Dependent variable: Operational sustainability of pond |             |                    |
| 1     | Surplus arrangement                   | -0.44       | *                  |
| 2     | Storage to catchment ratio            | 2.08        | 11%                |
| 3     | 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 |           |                    |
| 1     | Distance from village                 | -2.20       | 10%                |
| 2     | Accessibility                         | 2.29        | 7%                 |
| 3     | 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 |             |                    |
| 1     | PRI functionality index               | 6.63        | 8%                 |
| 2     | Collection time change perception     | 23.5        | *                  |
| 3     | Household dependent on resource       | 0.001       | *                  |
| 4     | BPL household                         | 0.007       | *                  |
| 5     | Gross benefit from pond               | 0.00002     | 20%                |
| 6     | Private water source                  | -0.70       | *                  |
| 7     | 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

## Table 6: Maintenance and conflict management of selected ponds.

| Pond Number | Village name | Village population | Animal Population | Pond storage volume (m³) | Pond water usage | Pond Maintenance | Social conflict management |
|-------------|--------------|--------------------|-------------------|--------------------------|------------------|------------------|---------------------------|
| 1           | Pipil        | 760                | 750               | 100200                   | Domestic, animal, irrigation | Poor             | Poor                      |
| 2           | Zinkhar      | 823                | 1520              | 240000                   | Domestic, animal  | Good             | Good                      |
| 3           | Tagadi       | 336                | 106               | 450000                   | Domestic, animal  | Good             | Good                      |
| 4           | Bahadi       | 45                 | 23                | 520000                   | Domestic, animal  | Good             | Good                      |
| 5           | Jaska        | 384                | 487               | 1029200                  | Domestic, animal irrigation | Poor             | Good                      |
| 6           | Khasta       | 3885               | 382               | 550000                   | Domestic, animal  | Poor*            | Poor*                     |
| 7           | Paccham      | 2250               | 1270              | 349200                   | Domestic, animal  | Poor             | Good                      |
| 8           | Fatehpur     | 574                | 180               | 225000                   | Domestic, animal  | Good             | Good                      |
| 9           | Haripur      | 282                | 50                | 207460                   | Domestic, animal  | Good             | Good                      |
| 10          | Khadol       | 747                | 445               | 1220400                  | Domestic, animal, irrigation | Poor             | No conflict               |
| 11          | Rayaka       | 784                | 193               | 124360                   | Domestic, animal irrigation | Poor*            | No conflict               |
| 12          | Morasiya     | 750                | 150               | 495900                   | Domestic, irrigation | Good             | No conflict               |
| 13          | Vagad        | 2100               | 1119              | 46015                    | Domestic, animal  | Good*            | No conflict               |
| 14          | Gunjar       | 12590              | 913               | 580000                   | Domestic, animal  | Good             | No conflict               |

*Sum of more than one pond volume
*Includes all the structures
Domestic use includes cloth washing
such as tubewells. PRI functionality can, therefore, be strengthened 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 resources. These observations find support from similar observations elsewhere [15,16]. Both these groups were poorly represented in most of the panchayat body. The weak sensitivity of PRI towards these community based natural resources can also be partly explained in terms of network of Narmada Canal and pipeline to villages to meet largely domestic uses, animal uses like bathing, maintaining hygiene and in some villages drinking.

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. The new institutional structures introduced under gender-equity based participatory models of local governance seek to balance out the inequalities by offering a platform or space where women can come together alongside men 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 [17,18]. Similarly, technical design and scientific planning in creating water resources would go a long way in not only serving the rural community but also efficiently as people’s perception about resource utility was positively higher in case of ponds with right technical parameters. Storage to catchment ratio of more than 0.1 or more has been suggested appropriate [13] for pond utility such as aquaculture. Such ponds with water for sufficiently longer period of time would also serve other purposes of rural livelihood.

Further technical examination in terms of geo-hydrological factors contributing to efficient pond water delivery would further enhance the utility of such studies. There is debate on downstream water flow effect of watershed management programme being under taken in the country. Large scale implementation of these programmes and their impact on health of these ponds needs further exploration as pond health affects their functionality affecting people’s perception for or against their involvement in the regular maintenance of these traditional sources of water. In the backdrop of poor perception about services delivered by pond, the financial resources generated are also adversely affected. Ponds, which traditionally have been the life line of a large section of Indian rural population, would be better managed if social factors are understood in the larger geo-hydrological context. The interplay of such technical and social factors can be better examined, understood and addressed if policy makers, local stakeholders and scientific community are brought to one platform and the cause-effect relationships amongst various region specific factors are established scientifically. The framework used in this study is one attempt. However, more efforts are required to test, modify and improve such models across the different socio-cultural and hydrological regions.

Notes

In the Fourth Plan, the concept of No Source Village (NSV) was introduced to identify problem villages with inadequate supply of water, and accordingly a village was an NSV if it did not have a reliable source of water. A village is a no source village if it has any of the following characteristics: (1) No public well, (2) has a public well that dries up in summer making villagers travel more than 1 km to fetch water, (3) a source of water supply more than 1 km away, (4) no possibility of a well, needed a tube well for drinking water, (5) there is a public well, but the supply is below 70 lpcd, (6) non potable water supply [19].

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