Irrigation & Drainage Systems Engineering

Research Article | Open Access

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

Pande VC[1]*, Bagdi GL[1] and Sena DR[2]

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

***Corresponding author:** Pande VC, Central Soil and Water Conservation Research and Training Institute, Research Centre, Vasad-388306 (Anand), Gujarat, India, E-mail: vcpande_2000@yahoo.com

Received August 02, 2013; **Accepted** September 10, 2013; **Published** September 20, 2013

Citation: Pande VC, Bagdi GL, Sena DR (2013) Physical and Social Factors in Management of Community Based Water Storage Structures in Gujarat: An Institutional Analysis of Local Governance. Irrigat Drainage Sys Eng 2: 108. doi:10.4172/2168-9768.1000108

Citation: Pande VC, Bagdi GL, Sena DR (2013) Physical and Social Factors in Management of Community Based Water Storage Structures in Gujarat: An Institutional Analysis of Local Governance. Irrigat Drainage Sys Eng 2: 108. doi:10.4172/2168-9768.1000108

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.

Citation: Pande VC, Bagdi GL, Sena DR (2013) Physical and Social Factors in Management of Community Based Water Storage Structures in Gujarat: An Institutional Analysis of Local Governance. Irrigat Drainage Sys Eng 2: 108. doi:10.4172/2168-9768.1000108

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, 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 [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.

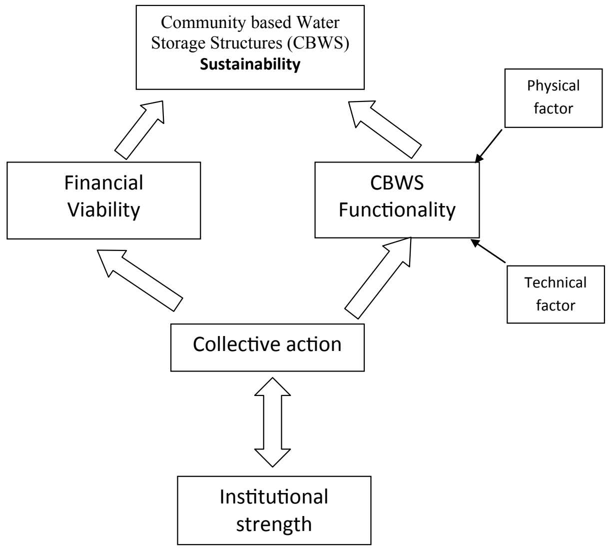

Figure 2: Institutional governance framework adopted for study.

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.

$\pi_i = e^{z}i/1+e^{z}i = 1/1+e^{-z}i$

This can be written as;

$z_{i=} \log(\pi i/1-\pi i)$

Where,

π_i is the probability the ith case experiencing the event of interest

z_i is the value of the unobserved continuous variable for the ith case

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

$Z_i = b_0 + b_1 X_{i1} + b_2 X_{i2} + \ldots + b_p X_{ip}$

Where,

X_{ij} is the jth predictor for the ith case, j=1, 2, …p

b_j is the jth coefficient

p is the number of predictors

If Z were observable, we fit a linear regression to Z. However, since Z is unobserved, you must the predictors are related to the probability of interest by substituting for Z.

$\pi i = 1/1+e^{-(b_0 + b_1 X_{i1} + ... + b_p X_{ip})}$

The regression coefficients are estimated through an iterative maximum likelihood method.

Pond operational functionality model:

Y=f (X_1, X_2, X_3, X_4) … (1)

Dependent variable:

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

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

Independent variables:

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)

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 (X_1, X_2, X_3, X_4) … (2)

Dependent variable:

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

Independent variables:

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=Use restriction (All uses (domestic, animal, irrigation)=1, otherwise=0)

X_4=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 (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 CBWS (Positive change=1, no change=0)

X_3=Number of household dependent on resource (Nos.)

X_4=Number of BPL household (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)

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

Citation: Pande VC, Bagdi GL, Sena DR (2013) Physical and Social Factors in Management of Community Based Water Storage Structures in Gujarat: An Institutional Analysis of Local Governance. Irrigat Drainage Sys Eng 2: 108. doi:10.4172/2168-9768.1000108

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 overflew 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
Khadol	1204	1200	500
Khasta	1600	1584	16
Haripura	880	780	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	-
Morasiya	900	600	33
Zinkhar	1000	917	167

Table 1: Village profile of selected water storage structures.

Village	Method of irrigation	Crops and area irrigated		Irrigation	Irrigation depth	Crop yield
		Name	Area (ha)	Nos.	Depth (cm)	(kg/ha)
Khasta 1	Lift irrigation through pipe	Wheat	2	2	3-4	1440
		Cumin	1	3	2-3	840
Khasta 2	Lift irrigation through pipe	Wheat	4	3	3-4	1200
Pipli	Lift irrigation through pipe	Cotton	6	3	4-5	2400
		Wheat	4	3	2-3	1200
		Cumin	2	4	2-3	840
Panccham	Lift irrigation through pipe	Wheat	30	2	3-4	960
		Cumin	10	3	3-4	720
Zinkhar*	-	-	-	-	-	-
Tagadi*	-	-	-	-	-	-
Bahadi*	-	-	-	-	-	-
Jaska 1	Lift irrigation through pipe	Cotton	50	3	4-5	3000
		Cumin	33	3	2-3	960
Jaska 2				-		
Rayka 1	Lift irrigation through pipe	Wheat	10	3	2-3	1200
		Cumin	4	3	2-3	720
Khasta*	-	-	-	-	-	-
Paccham*	-	-	-	-	-	-
Fatepur*	-	-	-	-	-	-
Haripur*	-	-	-	-	-	-
Khadol	Lift irrigation through pipe	Wheat	300	3	3-4	1200
		Gram	100	1	2-3	960
		Jowar Fodder	100	2	4-5	6000
Rayka 2	Lift irrigation through pipe	Wheat	50	3	3-4	1200
		Gram	10	1	2-3	960
		Cumin	20	3	2-3	600
		Jowar Fodder	20	2	2-3	4800
Rayka 3*	-	-	-	-	-	-
Morasiya	Lift irrigation through pipe	Cotton	25	7	4-5	3000
		Cumin	4	3	2-3	600
		Jowar Fodder	4	1	3-4	6000
Vagad 1*	-	-	-	-	-	-
Vagad 2*	-	-	-	-	-	-
Vagad 3*	-	-	-	-	-	-
Gunjar*	-	-	-	-	-	-

*No supplementary irrigation provided from pond

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

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	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

Table 3: Technical and physical attributes of village ponds.

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. In a few villages, poorer farmers still depended on the village pond even for domestic uses.

Logit and regression analysis results

The general description of the variables used in the study is given in Table 4. Based on the technical and social attributes the variables for which consistent data could be procured from beneficiaries were used for analysis.

The pond operational functionality model had operational sustainability index as dependent variable. This variable was measured as dichotomous variable in terms of water storage. If water in pond remained for more than six months, the value of this variable was taken as 1, if water remained stored for less than six months, the value was 0. The mean of the variable was 0.77 with a standard deviation (SD) of 0.43. The explanatory variables for the model included catchment land use, measured in terms of non-arable (1) and arable land (0), with mean 0.50 and SD 0.51; surplus arrangement, measured in terms of separate inlet and outlet (1) and no separate inlet and outlet (0), with mean 0.14 and SD; storage to catchment ratio, measured in terms of ratio of storage area to catchment area more than 0.1(1), otherwise (0), with mean 0.45 and SD 0.50 and pond seepage behavior, measured in terms of presence of seepage (0) and absence of seepage (1), with mean 0.72 and SD 0.45. The pond functionality perception from beneficiaries' view point was examined to understand the relationship and identify the factors that influence their perception about pond health. Such perceptions influence their involvement in pond management [14]. The dependent variable was measured as good status perception (1) and poor status perception (0) with mean 0.67 and SD 0.47. The explanatory variables viz., distance, accessibility, water use restriction and location had mean varying from 0.23 to 0.52 and standard variation, from 0.45 to 0.50. These variables were used as input in the software, SPSS 13 and analyzed using logistic regression module for best fit.

For the financial viability model, the dependent variable (financial viability index) was measured as an index with equal weightage given to each factor viz., fee collected for domestic, animal and irrigation uses, frequency of collection and mode of utilization. The variables were given values varying from 0 to 2. For fee collected a value was given '0', if no fee collected, '1' if less than Rs 100/- annum collected and 2, if more than Rs 100/- annum collected in case of a pond. The frequency of collection was valued as 0 (no collection), 1 (irregular collection) and 2 (regular collection). The fund utilization mode was valued as 0 (no utilization), 1 (decided by few) and 2 (decided with consensus). The index had mean 1.11 and standard deviation 0.17. The explanatory variables such as PRI functionality, perception about change in water collection time and water quality, private water source owned were dichotomous in nature with values 0 and 1. The remaining

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 percpetion model variable				
Dependent variable				
CBWS status	Perception about present status of pond	0.67	0.47	22
Explanatory 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
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 4: Model variables used in the study.

variables were measured as actually measured with relevant units. The dichotomous explanatory variables had mean varying from 0.70 to 1.11 and SD varying from 0.17 to 0.47. The number of households dependent on the resource varied from 15 to 1050, with a mean of 463 and SD 515. The BPL household, similarly, had mean 133 and SD 146. The gross benefits drawn from pond had mean Rs 5,00,498 and SD 6.57. This functional relationship was examined using the software, SPSS 13 with regression module.

The results of logit and regression model are given in Table 5. The variables were 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 community based natural resources. 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. 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 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

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

Pond Number	Village name	Village population	Animal Popula-tion	Pond storage volume (m^3)	Pond water usage	Pond Maintenance	Social conflict management
1	Pipli	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	52000	Domestic, animal	Good	Poor
5	Jaska	384	487	1029200	Domestic, animal irrigation	Poor	Good
6	Khasta	3885	382	55000*	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	49590	Domestic, irrigation	Good	No conflict
13	Vagad	2100	1119	46015*	Domestic, animal	Good@	No conflict
14	Gunjar	12590	913	58000	Domestic, animal	Good	No conflict

*Sum of more than one pond volume
@ Includes all the structures
Domestic use includes cloth washing

Table 6: Maintenance and conflict management of selected ponds.

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 such as tube wells. 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 resource. These observations find strength 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 (NSU) 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].

References

1. Edwards V M, et al. Developing an Analytical Framework for Multiple-Use Commons. Journal of Theoretical Politics. 1998; 10 (3): 347–383.
2. Taylor M. Governing natural resources. Society and Natural Resources. 1998; 11 (3): 251–258.
3. Agrawal A. Sustainable Governance of Common-Pool Resources: Context, Methods, and Politics. Annu Rev Anthropol. 2003; 32: 243-262.
4. Kiss A. Living with wildlife: wildlife resource management with local participation in Africa. World Bank Technical Paper, Washington, DC. 1990; WTP 130.
5. Wade R. Village Republics: Economic Conditions for Collective Action in South India. Cambridge: Cambridge University Press, 1988.
6. Ostrom E. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge: Cambridge University Press, 1990.
7. Heltberg R. Determinants and Impact of Local Institutions for Common Resource Management. Environment and Development Economics. 2001; 6: 183-208.
8. Mitchell B. Integrated Water Management: International Experiences and Perspectives. Belhaven Press, London, 1990.
9. Bandaragoda DJ. Status of institutional reforms for integrated water resources management in Asia: Indications from policy reviews in five countries. International Water Management Institute (IWMI), Colombo. 2006; Working Paper 108.
10. Rydin Y, et al. Networks and Institutions in Natural Resource Management. Edwar Elgar Publishing Limited, Cheltenham, UK, 2006.
11. Janakarajan S. In Search of Tanks Some Hidden Facts. Economic and Political Weekly, 1993; 28 (26): A53-A60.
12. Denzin NK. The Research Act: A Theoretical Introduction to Sociological Methods. McGraw-Hill, New York, 1978.
13. Kovari J. Considerations in the selection of sites for aquaculture. United Nations Development Programme, Food and Agriculture Organization of the United Nations, Rome, 1984.
14. Tyson B, et al. Facilitating Collaborative Efforts to Redesign Community Managed Water Systems. Applied Environmental Education and Communication. 2011; 10 (4): 211-218.
15. Aladuwaka S, et al. Sustainable development, water resources management and women's empowerment: the Wanaraniya Water Project in Sri Lanka. Gender & Development. 2010; 18 (1): 43-58.
16. Barnaud C, et al. Dealing with Power Games in a Companion Modelling Process: Lessons from Community Water Management in Thailand Highlands. The Journal of Agricultural Education and Extension. 2010; 16 (1): 55-74.
17. UNDP. Mainstreaming gender in water management: a practical journey to sustainability. UNDP/BDP Energy and Environment Group, New York, 2003.
18. GWA. Advocacy Manual for Gender and Water Ambassadors. WEDC (for GWA), Leicestershire, 2002.
19. Hirway I. Ensuring Drinking Water to all: A Study in Gujarat. Paper submitted to the 4th IWMI-TATA Annual Partners Research Meet, 2005.

Citation: Pande VC, Bagdi GL, Sena DR (2013) Physical and Social Factors in Management of Community Based Water Storage Structures in Gujarat: An Institutional Analysis of Local Governance. Irrigat Drainage Sys Eng 2: 108. doi:10.4172/2168-9768.1000108