IMPROVING CANAL WATER MANAGEMENT THROUGH PARTICIPATORY APPROACH: A CASE STUDY ON SECONDARY CANAL (POTHO MINOR), SINDH, PAKISTAN

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ABSTRACT

Improvement in canal water management requires the strong and stable relationship and trustworthy among the water users in the command area of Watercourse (Tertiary canal) and Distributary/Minor (Secondary canal) and canal operating agencies. The potential conflicts on water distribution equity among the water users at secondary level canal could be achieved through establishing Farmer Organization (FO) at Distributary and Watercourse Associations at watercourse, training to the farmers, appropriate water measuring mechanisms and proper maintenance.

Potho Minor is the secondary canal level network of irrigation system in Pakistan. The Farmer Organization on the minor was established in 2000. However, the process of social mobilization was started in 1999. Present study was carried out to assess the status on water delivery to farmers, water use efficiency and farmer's role for improving water distribution for sustainable irrigated agriculture.

Based on data collected and analyzed in command area of the Minor, the status of irrigation water management demonstrates that the water delivery to the farmers along the minor length fluctuates between 25-190 percent, water availability is only 68 days out of 168 days allocated for the crop season, but it is abundant as estimated 5.9 mm/day against the required 2.83 mm/day. This all mismanagement has resulted in 34 percent system efficiency and 10 to 114 percent watercourse-wise efficiency.

However, the participation of water users from Watercourse Associations and Farmer Organization in the maintenance of the distributaries/minors for sustainable irrigation management has proved that the cost of maintenance can be significantly minimized and work can be done in time. The maintenance cost estimated was about US$ 0.25 (Pak Rs. 15) per acre of land and the substantial benefit accrued was observed that the head-tail water delivery performance ratio improved significantly, though the head DPR was substantially decreased.

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Further, paper highlights the lessons learned from the maintenance activities and concerns for the future of Farmer Organizations.

INTRODUCTION

In Sindh, Pakistan the institutional reforms in irrigation sector started in 1997 and Sindh Irrigation and Drainage Authority (SIDA) was established. The over all objective of the institutional reforms is to operate and maintain Irrigation and Drainage System with reliable service delivery on condition agreed up on by the end users.

The differences in water deliveries to different sub systems, head-end areas receive significantly more water than their share, and tail-end areas receive comparatively less irrigation water, therefore, the actual water distribution pattern failed to meet the targets set down at the start of each season. (Kijne D. Murray-Rust and W. Snellen 2002, and N.Bhutta and Vander 1992).

The most important component of irrigation system is to organize farmers. Once organized in an effective manner, farmers will demand equitable water distribution. In fact, the organization cannot be sustained unless this objective is achieved. Also, they will have a keen interest in reducing discharge variability. The main advantage is that significant increases in agricultural productivity can be expected (Zaigham and M.Kuper 1998).

The poor function of the irrigation system in Pakistan has been since the year 1960’s. This under performance is mainly due to the scarcity of surface water. The previously planned scarcity of surface water now manifests itself inadequacy, un-reliability and inequity in the distribution of surface water for farmers at watercourse. Now, these discrepancies lead to other problems like water logging and salinity (Stosser 1997).

There is a need for all countries in the region to upgrade their human resources in number and know-how and improve their institutions so as to provide an efficient working environment in which trained human resources can be most effective. Most of the countries, however, are sufficiently aware of the problems. The technical know-how exists or gaining access to it is relatively easy, but there are major difficulties and a lack of experience in managing the application of technology on a large scale in order to solve and avoid problems or to establish desirable programs or practices. In most countries, for example, the technical community is well aware of what constitutes good irrigation, of how to be water efficient, how to determine crop consumptive use and irrigation scheduling, and how to avoid salinization and erosion. What is not so well known is how to structure and implement efficient and cost-effective procedures to “set in” the available knowledge within water user communities to ensure continuous application of proven practices, thereby accomplishing sustainable agriculture (J. F. Alfaro 1995).

The performance evaluation of an irrigation system at primary and secondary sub-system levels is in isolation from the performance evaluation of an irrigation system at watercourse and farm level that would not provide full understanding of the system. However, little work has been done on the performance of the surface water supply system at watercourse level (Perry 1996).

An orderly system of distributing water must be in place through some existing and respected regulatory framework for allocating water among farmers—rules and procedures defining rights and responsibilities; priorities in case of shortage or excess supplies; penalties for breach of rules, and so on. If this is not the case—or if regulations are not observed (if farmers take water at will, manipulate gate settings, tolerate significant interference in water, or do not pay assessed charges) then there is no immediate scope for improving water distribution through pricing (C.J. Perry 2001).

STUDY AREA

Potho Minor Farmers Organization was formed in 2000 and an agreement was signed with Canal Area Water Board (CAWB). Process of social mobilization for forming the organization was started by the International Water Management Institute (IWMI) in 1999. The responsibilities of FO includes: Operation and maintenance of minor and drainage infrastructure, assessment and collection of abiana (Water charges), water management for fair distribution of water to the

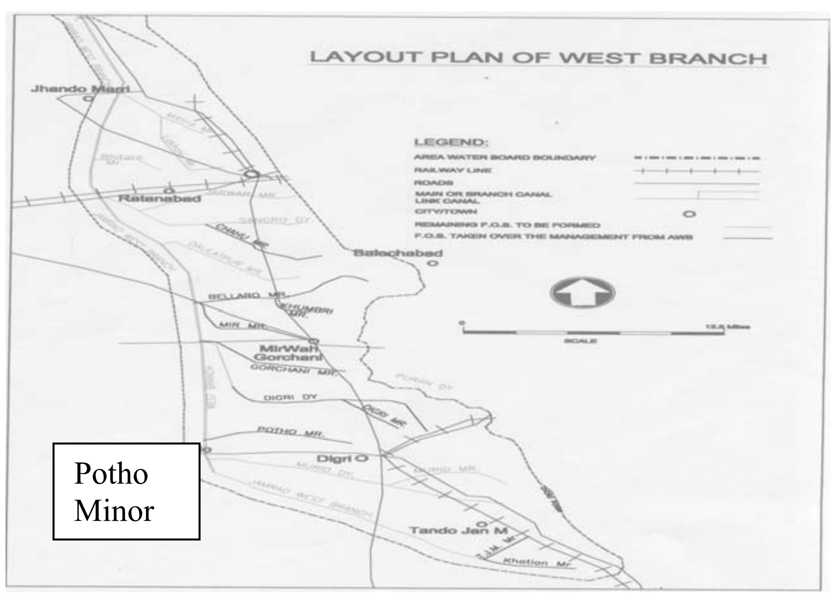

Figure 1. Location Map of Potho Minor Off taking from West Branch of Jamroa Main Canal.

farmers/ water users as per their entitlement, receive water supply as per the design discharge at head regulator of the minor and conflict resolution if arises at any time. The location map and salient features of the Minor are shown in Figure 1 and Table 1. Note: Data was recorded from September 2002 to March 2003.

Table 1. The Salient Features of the Potho Minor.

Description	**Detail**
Name of minor	Potho minor
RD taking off from West Branch	215.0
Design Discharge (cusecs)	29.9
Length of minor (RD)	33.11
Number of water courses	19
Number of lined water courses	3
Gross Commanded Area(acres)	9063
Cultural Commanded Area (acres)	8 396

RD= Reduced distance

DATA COLLECTION

At Minor level, gauges were installed at head-middle and tail sections of the Minor. The Minor length was divided in three equal parts considering command area. These gauges were calibrated and rating was developed (Discharge vs. water depth). To get the accurate data, the gauges were periodically checked and calibrated accordingly.

At watercourses level, the rectangular sections having length 20 feet, depth 2 feet and width 2 feet were constructed in each watercourse. The purpose of having the rectangular section was to have the stable section where the gauges can be installed or used. The sections were calibrated and ratings were developed for all watercourses. The outlet structures were not used as measuring device because most of them were tampered with or frequently being tampered.

Farmer Organization (FO) and Watercourse Associations (WCAs) were actively involved in gauges installation, construction of rectangular sections and daily monitoring gauge levels and recording on record book. To make reliable data the FO members were provided training on water measurement, canal operation, development of a business plan, collection of irrigation fees and development of effective and manageable maintenance plans

Crop data was surveyed physically and recorded for each watercourse separately. Using this data cropping pattern and cropping intensity were obtained. However, the design data was collected from the Irrigation and Power Department, Government of Sindh.

RESULTS AND DISCUSSIONS

Water delivery and distribution system

Total water delivery to the head was estimated 6177 acre feet (AF) for a period of 68 days out of 168 days running of the Minor for full crop season (winter season); if, the continuous full supply of water would have been given according to design then the minor would have received 9963 AF. This actual delivery of 6177 AF is 62% of design delivery, whereas, the Minor was closed in rotation for more than 60% of winter) season.

Figure 2, shows that the fluctuation in head gauge is varying from 25% to 190% in the Rabi season. More variation has been taken place in the months of November, January and March. The variation at middle gauge is between 45% and 26% in Rabi season. However the major variation at middle gauge has taken place in the months of December, January and March. The fluctuation at the tail gauge has remained between 50% and 28%. The worst effected months were November, December, January and March.

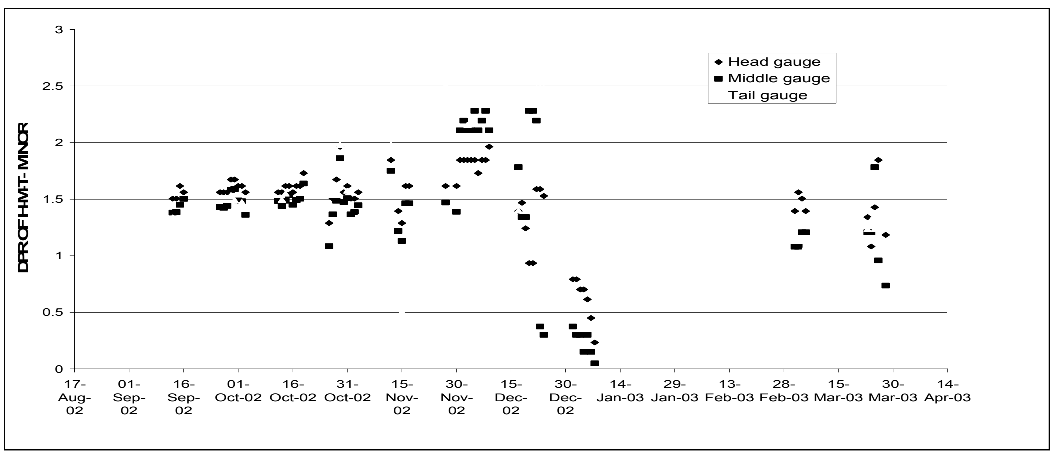

Figure 2: Water Delivery Performance Ratio at Head, Middle and Tail Gauges of the Minor

Table 2. Observed Discharge and Volume Indices for all Watercourses

Water-courses number	Design discharge cusecs	Actual discharge when flowing (68 days), cusecs	Average actual discharge over Rabi season (168 days), cusecs	Volume, acre-ft
151/2R	1.71	4.76	1.89	628.60
151/3R	1.50	2.53	1.01	333.74
151/4R	1.00	1.34	0.53	176.38
150/2L	1.14	1.96	0.78	259.16
153/1R	0.90	2.03	0.81	267.48
150/3L	0.77	1.81	0.72	238.84
154/1L	1.68	2.63	1.05	347.48
161/1AR	0.95	1.76	0.70	231.80
161/1R	1.13	1.96	0.78	259.08
160/1L	1.84	2.72	0.95	315.20
160/4AR	1.13	1.71	0.60	198.12
160/4BR	0.80	2.76	0.97	320.50
160/2L	1.80	2.96	1.03	343.56
169/1BR	0.96	2.74	0.96	317.38
160/3R	0.18	1.93	0.67	224.02
160/4L	0.81	2.11	0.74	244.66
164/2T	1.50	2.63	0.92	304.84
164/1AT	2.10	2.53	0.88	293.50
169/1AT	1.08	1.48	0.52	171.16

Table 2 expresses the overall view that how each watercourse command area is receiving actual water supply against the designed water supply and crop water need. The system (all command area and watercourses) receives water 68 days against the planned crop season of 168 days (60% system is closed). However, the actual supply in each watercourse is varying between 345% and 120% of designed discharge, again if, it is distributed among all watercourse for planned 168 days of crop season, the average discharge becomes between 110% and 53%.

Water Application in Command Area of Watercourses.

The assessment of water application in command area of the Minor is based on the actual measurements of water flows and cropped area for the Rabi (winter) season. The results are shown in Table 3.

Table 3: Delivered Volume, Required volume, Efficiency and Sufficiency of Watercourses

Watercourse number	Measured volume (acre-feet)	Water requirement (IPD 1993)* (acre-feet)	Efficiency %	Sufficiency %
151/2R	629	88	10	715
151/3R	334	124	26	269
151/4R	176	88	36	200
150/2L	259	118	32	220
153/1R	267	126	33	213
150/3L	239	51	15	468
154/1L	347	179	37	194
161/1R	232	152	47	152
161/AR	259	168	46	154
160/1L	315	184	42	171
160/4AR	198	213	76	93
160/4BR	321	109	24	293
160/2L	344	128	27	268
169/1BR	317	110	25	288
160/3R	224	31	10	713
160/4L	245	78	23	314
164/2T	305	219	51	139
164/1AT	294	186	45	158
169/1AT	171	275	114	62
Totals	5476	2628	Avg: 34	Avg: 208

(*The calculations are based on recommended values of crop water requirement published in irrigation manual by Irrigation and Power Department, Government of Sindh 1993.)

The results indicate that the water use efficiency of each watercourse command area is ranging between 10% to 114%. If the irrigation water is properly managed and applied then the efficiency could have been much higher as determined ranging between 715% to 93%. The data gives the impression that the water was not properly distributed and managed as per crop need and soil holding capacity.

Table 4. Received Volume, Culturable Command Area (CCA), Potential Cropped Area and Potential and Assessed Cropping Intensity for all Watercourses.

Water-course number	Received volume, acre-feet	CCA, acre	Delivered volume over cultivated area, feet/acre	Potential area, acre	Potential cropping intensity %	Assessed intensity %
151/2R	629	614	1.02	330	54	8
151/3R	334	548	0.61	221	40	15
151/4R	176	357	0.49	137	38	19
150/2L	259	392	0.66	165	42	19
153/1R	267	375	0.71	164	44	21
150/3L	239	274	0.87	157	57	12
154/1L	347	596	0.58	200	34	17
161/1R	232	339	0.68	174	51	34
161/AR	259	454	0.57	175	38	25
160/1L	315	649	0.49	211	33	19
160/4AR	198	393	0.50	134	34	37
160/4BR	321	279	1.15	240	86	29
160/2L	344	648	0.53	241	37	14
169/1BR	317	272	1.17	210	77	27
160/3R	224	69	3.25	187	272	38
160/4L	245	286	0.86	183	64	20
164/2T	305	520	0.59	176	34	24
164/1AT	294	745	0.39	174	23	15
169/1AT	171	253	0.68	68	27	43
Totals	5476	8063	Avg: 0.68	3449	Avg: 43	Avg: 21

Table 4 shows that water was delivered for each acre of culturable command area on average 0.68 foot. However, water delivery for watercourses varies between 3.25 acre-feet in 160/3R to 0.39 acre-feet in 164/1AT.

The potential cropped area in the Minor, using averages for the intensities of different crops, would have been 3449 acres or 43% of the CCA. However, the potential cropping intensities of the watercourses vary between 23% and 86%. Only for watercourse 160/4AR, the cropping intensity is 37% as was assessed while the delivered volume of water is only enough for 34%, here shows that the deficit irrigation was applied. However, almost for all watercourses the potentially cropped area is higher than the assessed, therefore, the delivered volume is enough for 27% designed cropping intensity. It is difficult to exactly interpret the data in Table 5. Nevertheless, the analysis provide insight in the water distribution, its use, the quality of assessment, possibly changes in CCA and many other things.

Role of Farmer Organizations

Farmer Organizations established in Sindh Province including Potho Minor Farmer Organization have been given responsibility of operation and maintenance of the secondary channel (Distributary/minor level canals). The performance assessment has been made for some of the FOs including Potho Minor.

Table 5. Maintenance Input into FO Channels.

Distributary	Man-days	Tractor hours	Imputed Cost (Rs)	Earthwork (m^3)	Cost (Rs/ha)
Heran	1157	58	124100	7411	24.85
Khadwari	301	16	49275	n/a	39.59
Rawtiani	586	35	64025	1351	17.50
Bareji	1020	14	105700	5601	18.23
Mirpur	1311	120	172650	9993	26.29
Potho	***979***	***17***	***113611***	***8138***	***34.80***
MAW	427	30	44625	3806	28.76
DhoroNaro	2055	292	249375	7376	46.03

The imputed cost of this activity is calculated on the typical labor and machinery hire rates prevailing at the time of the survey. Based on an average of Rs. 100 per day per person and between Rs.150-175 per tractor-hour, the grand total is just over Rs. 800,000. On an average basis the cost is almost Rs.25 per ha ($0.45) which represents about 40% of the typical irrigation water fee or abiana that farmers are expected to pay.

Table 6. Hydraulic Condition of Distributaries before and after Maintenance

Distributary	Before Desilting			After Desilting		
	Head	Tail	Ratio of Head:Tail	Head	Tail	Ratio of Head:Tail
Heran	1.36	0.38	3.53	1.31	0.51	2.55
Rawtiani	1.71	1.71	1.00	1.54	1.71	0.90
Tail	1.49	1.20	1.23	1.15	0.96	1.20
Mirpur	1.02	0.39	2.64	0.94	0.66	1.44
Bareji	2.13	1.63	1.30	2.13	2.36	0.90
Sanrho	1.29	1.11	1.16	1.34	1.58	0.85
Belharo	1.11	0.36	3.07	1.07	0.79	1.35
Digri	1.17	1.12	1.04	1.04	0.90	1.16
Potho	***1.42***	***1.15***	***1.23***	***1.20***	***1.12***	***1.07***
Khatian	1.31	0.65	2.00	1.25	1.35	0.92
Bagi	0.58	0.80	0.72	0.71	1.36	0.52

Looking at the ratio between head and tail delivery performance ratio (DPR) values before desilting, the degree of inequity can be clearly seen from Table 6. In only one canal (Bagi minor) was tail end DPR values higher than the head: in all other canals head end values were higher than tail end. At Heran and Belharo head end values were over three times as high as tail end values.

After desilting the picture changed considerably. Average discharges into canals were only 20% above design: overall in the area discharges are low after desilting because it is the coolest season of the year and wheat in some areas is beginning to mature. However, tail end DPR values were, on average, also at 120% of design indicating almost uniform distribution. Data demonstrate that the inequity between head and tail was substantially reduced. However, many tail end areas got more water than the head, but in reality this will slowly be reversed as canals silt up again during the year.

LESSONS LEARNED AND FUTURE CONCERNS FOR MAINTENANCE ACTIVITIES

The ability of Farmer Organizations to take substantial responsibility for maintenance at secondary canals in Pakistan is a relatively recent phenomenon and certainly one that ten years ago would have been viewed as more or less impossible. However, the process is still in initial stage and there remains a lot of work to be done to develop a sustainable approach for operation and maintenance.

It is also clear that in a comparatively short period of time, and certainly in no more than two or three days if people work hard, it is possible to completely desilt secondary canals and restore them to their original design condition. This level of input does not seem unreasonable and we can speculate that if other conditions remain in place then it will be possible to expect similar inputs into the future.

There were substantial hydraulic benefits. In virtually all locations the inequity of water distribution between head and tail was reduced, and in several cases previous inequities were reversed with tail end water users getting a slightly higher proportion of available water than head enders.

Based on these concerns it would be premature to suggest that one the basis of a single activity within the context of a fairly intensively managed that the Farmer Organizations can undertake all aspects of maintenance into the future. There is still a long way to go before they develop the technical skills and the managerial capacity to maintain canals, repair infrastructure, and upgrade it as and when the need arises.

On the other hand, the Irrigation Department has been unable to do this for many years despite technical training, manuals and guidelines, and financial resources. So the result may be one that is no worse than previous conditions but one that does hold out some hope for the future that the current water users have the responsibility for looking after their own affairs.

CONCLUSIONS

The system overall views that it has received water 68 days against the planned crop season of 168 days (60% system was closed). However, each watercourse was getting discharge between 345% and 120% of designed discharge. If, the available water would have been distributed among all watercourses for planned 168 days of crop season, the average discharge could have been between 110% and 53% and that rotation period could have been reduced significantly.

The water use efficiency of each watercourse command area was between 10% and 114%. If water was properly managed and applied, then the efficiency could have been reached between 715% and 93%. This poor efficiency is due to unreliable supply of water and continuous rotation system. This also shows that there is no check and balance system and coordination among stakeholders to manage the irrigated agriculture system in proper manner.

The cropping intensities in all watercourses command area were between 43% and 8%. If, water were properly managed then potentially cropping intensities of the watercourses would have been between 86% and 23%. Therefore, the delivered volume of water would have been enough for designed cropping intensity of 27% of winter season and the average potential cropping intensity for the Minor command area would have been 43%, not the 21%.

Farmer Organizations have proved that the collective efforts not only improve the water distribution equity among water users and ensure tail reach supply but have significantly reduced the maintenance cost and completion of work in time. This all has achieved because of capacity building of the water users. If, water is reliably supplied to the water users then application efficiency will significantly improved in future.

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