IMPACT OF FARMER-MANAGED MAINTENANCE OF SECONDARY CANALS ON WATER DISTRIBUTION EQUITY: A CASE STUDY FROM SINDH, PAKISTAN

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ABSTRACT

International Irrigation Management Institute (IIMI) carried over a pilot action research study on farmer managed irrigation system (FMIS) in Sindh Province of Pakistan. Overall fourteen Farmer Organizations (FOs) on distributary channels were formed. In order to ensure success of this participatory management, the FO members were trained in organizational management, operation and maintenance (O&M) of channels and financial aspects. The study focuses on impact of farmer-managed maintenance on water distribution equity and resources mobilization.

In conjunction with a program to organize water users at secondary canals in Sindh, IIMI staff made observations on the physical conditions before and after the maintenance campaign in January 2000 and actual inputs made by members of Farmer Organizations. In a one-week period water users contributed over 7,800 man-days of labor and 582 hours of tractor operation in eight secondary canals, and removed over 43,000 cubic meters of sediment. The imputed cost of these contributions exceeded over Rs.900,000 ($15,000) or almost Rs.30 per hectare ($0.50).

The hydraulic benefits were substantial. Comparing water deliveries into the head and tail reach of each canal before desilting, head end areas received roughly 68% more water than tail enders. After desilting the head end areas only received 14% more water, and in six of the eleven canals where water measurements were taken, tail end areas actually received more water than head end areas.

Despite the benefits that accrued, there is concern for the long-term sustainability of the improved performance. There is no systematic monitoring program that enables operation and maintenance to be linked and no proper maintenance of control infrastructure to complement desilting. Until these institutional changes occur, operation and maintenance will remain a largely ad-hoc activity.

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INTRODUCTION

Maintenance in the Context of the Design of Canals in Pakistan

There can be no doubting the importance of maintenance as an integral component to the successful performance of irrigation systems. There are many generic manuals available such as those produced by ASCE (1980), ICID (1989) and Snellen, for FAO (1996), and there are innumerable O&M manuals for national and provincial Irrigation Departments and for specific projects for new or rehabilitated irrigation systems. Few textbooks fail to stress the importance of maintenance, and some books are largely focused on the problem (Skogerboe and Merkley, 1996, and Verdier and Millo, 1994, are good examples).

Yet the stark reality is that irrigation performance in most irrigation systems appears to continue to decline, and guidelines or standards for maintenance remain ignored or only partially followed. Further, this is taking place in many countries where there is in process a transfer of operation and maintenance responsibilities that brings in a new set of managers and system operators who may not have had prior experience in running a focused and systematic maintenance program.

To ensure that canals did indeed function as designed, three pieces of data were required to be collected that helped the operational staff of the irrigation agencies to determine whether or not canals were performing as expected (Sindh Irrigation Department, 1995):

- Daily water levels at the gauge at the head of secondary canals, converted to discharge using a rating table that was meant to be revised at least once a year;
- Daily water levels at the gauge installed at the tail of the secondary canal, which are normally designed to be 0.6 feet (18.3 cm)
- Monthly measurements of water levels in the secondary canal adjacent to each outlet

Using these three pieces of information it is easy to determine whether or not the canal system is functioning properly. The head gauge shows whether or not the incoming discharge is at designed level, and if not then the control structure at the head of the secondary canal must be adjusted. The tail gauge should read the desired target level if the head discharge is at design. If it is not, then something has gone wrong and a field inspection is required to find out why this discrepancy has occurred.

However, if there are persistent discrepancies the problem is likely to be one of sedimentation or erosion that has caused water levels along the canal to deviate from design, and therefore change the discharge passing through each outlet

structure. The third piece of data, the monthly water level readings entered in the "H" register, was specifically collected to allow engineers to determine where such problems were occurring and to take necessary remedial measures such as desilting or bank restoration.

As long as the three sets of data showed no problems, engineers could be assured that water distribution was at or very close to the equity expected of the system. As long as illegal actions at individual watercourses could be kept under control, and as long as discharges were at or close to design, inequity could only occur through improper maintenance. From this we can conclude that maintenance of secondary canals is the key to water delivery performance in supply-based canals such as those of Pakistan and Northwest India.

STUDY AREA

Pilot Farmer Organizations in Sindh

The pilot program not only dealt with the creation of the structure of watercourse organizations at watercourse level and federated at distributary level and formed the Farmer Organizations (FO), but also provided technical support and training in various aspects of irrigation and drainage system operation and maintenance. FO members received training on water measurement, canal operation, development of a business plan, collection of irrigation fees and development of effective and manageable maintenance plans. The FOs formed at different distributaries are indicated in Figure 1. However, the salient features of the pilot distributaries where hydraulic and diagnostic survey were carried out, are given in Table 1.

Table 1. Salient Features of the Pilot Distributaries.

Distributary	Length (Km)	Area (ha)
Heran	9.75	4994
Rawtiani	8.38	3658
Bareji	11.98	5797
Mirpur	14.63	6566
Potho	10.06	3264
MAW	5.18	1552
Khadwari	5.18	1245
Dhoro Naro	9.84	5418

Although the different FO groups had no legal requirement or responsibility to undertake maintenance at secondary canal level, they were keen to do something because they all suffered some form of water distribution inequity between watercourses. So as part of the pilot program it was agreed between the Irrigation

Department and each FO that was established by January 2000 to undertake self-help maintenance activities with technical support from the IWMI staff in the field. A total of eight FOs participated in structured maintenance planning, while an additional 4 undertook less structured maintenance where no hydraulic surveys were undertaken.

The approach followed is summarized in Table 2, that contains a set of logical steps to involve the water users in a program that should result in properly functioning canal once maintenance has been completed.

By and large each FO was able to undertake these activities with only minimal technical support from IWMI. The main areas of involvement of IWMI was in doing the surveys of the canals, estimating the work to be done and the actual work accomplished, and continuing the routine water measurement activities before and after maintenance.

Table 2. Maintenance Program for Farmer Organizations at Secondary Level Canals

Activity	Tasks
Problem Identification	• Meeting of FO committee before canal closure to identify problems resulting from degraded canal; • Motivate members to participate and contribute labor, funds and tractors
Hydraulic Survey	• Undertaken as soon as canal is closed • Measure cross-section every 1500 m • Measure long-section from head to tail • Compare to design drawing of canal
Walk-Through Survey	• FO committee members identify sections where desilting or bank repairs are required
Prioritization of Needs	• FO general meeting to discuss scale of work required • Consensus obtained on what to do as a priority • Estimation of costs involved and whether some work has to be contracted out • Set date for maintenance
Resource Mobilization	• Collection of necessary funds • Agreement for labor commitment of members • Identification of who will provide tractors
Maintenance	• Communal desilting and bank restoration until design conditions are restored
Evaluation and Feedback	• Assessment of labor and machinery inputs • Estimation of earthwork and bank work undertaken • Measurement of hydraulic performance

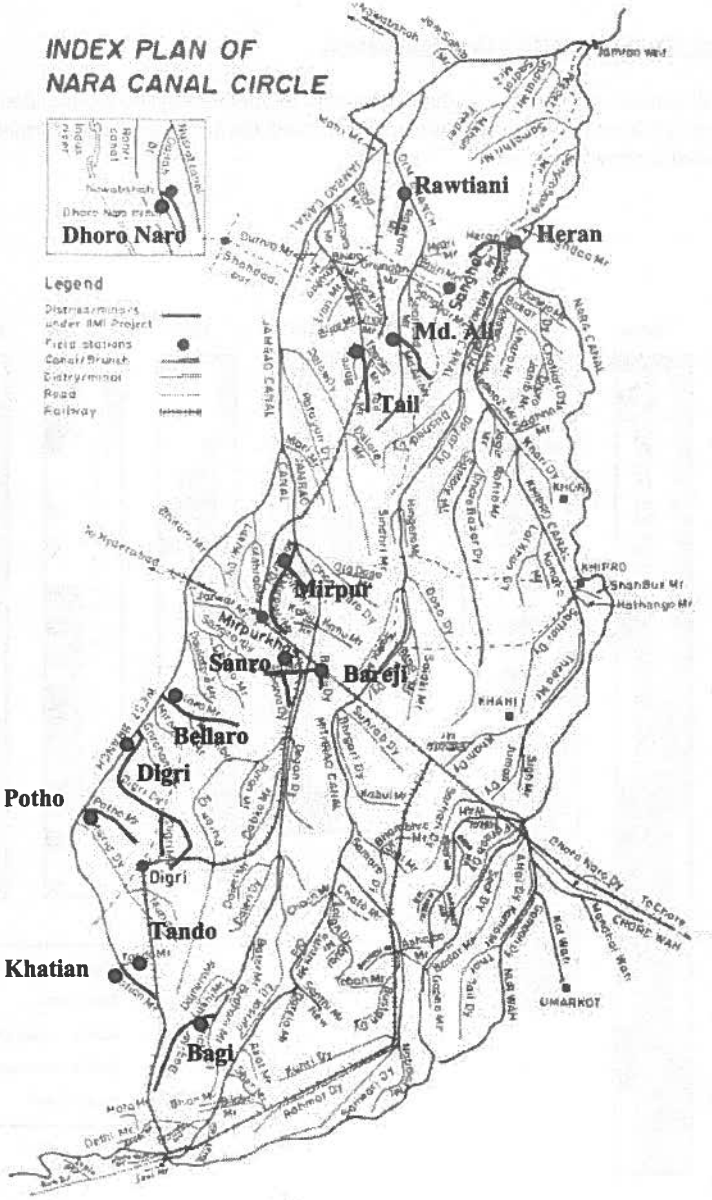

Figure 1. Location of IWMI Sample Secondary Canals in Sindh

Canal Conditions before the Maintenance

The diagnostic survey was conducted for each distributary by the FOs to identify the real problem of the distributary and prioritized the activities. The information gathered is shown in Figure 2.

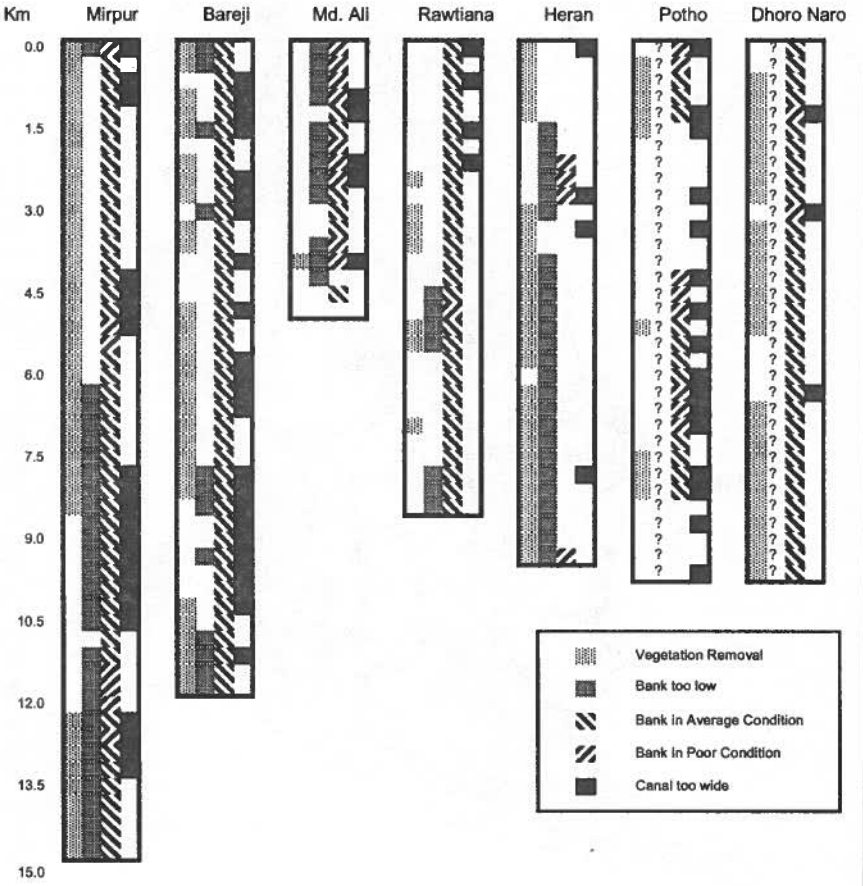

Figure 2. Maintenance Requirements.

RESULTS AND DISCUSSION

Maintenance Inputs

Labor Inputs. For an area exceeding 32,000 ha farmers provided over 7,000 man hours of voluntary labor and donated nearly 600 hours of tractor time. This represents an average of just over one person-day for 4.5 hectares (11 acres). It is clear that labor inputs were not directly matched to the amount of work actually required. In all canals there was a great deal of solidarity among water users who were keen to show the Irrigation Department that they were able and willing to undertake this work, and that they would be able to do so in the future once management transfer had occurred.

Table 3. Maintenance Inputs into Pilot Secondary Canals.

Distri-butary	Man-days	Tractor-hours	Imputed Cost (Rs)	Earth-work (m^3)	Work (man-days per ha)	Cost (Rs/ha)	Cost (Rs/ m^3)	Volume (m^3 per man-day)
Heran	1157	58	124100	7411	0.23	24.85	16.74	6.41
Raw-tiani	586	35	64025	1351	0.16	17.50	47.40	2.31
Bareji	1020	14	105700	5601	0.18	18.23	18.87	5.49
Mirpur	1311	120	172650	9993	0.20	26.29	17.28	7.62
Potho	979	17	113611	8138	0.30	34.80	13.96	8.31
MAW	427	30	44625	3806	0.28	28.76	11.72	8.91
Khad-wari	301	16	49275	n/a	0.24	39.59	n/a	n/a
Dhoro Naro	2055	292	249375	7376	0.38	46.03	33.81	3.59
Total	7836	582	923361	43678				
Average					0.25	29.51	22.83	6.09

Imputed and Actual Costs

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. This is a substantial saving for the government who would otherwise have had to pay those labor rates to accomplish the amount of work done. If the inputs were typical for all of Sindh then the total cost of maintenance for the Province would be something on the order of Rs.125 m or $2.25 m.

Sediment Removal

The volume of sediment removed was substantial, with over 40,000 cubic meters of material being cleaned out of the canals. Most of this material was used to repair banks and canal roads so the total distance of haulage was small. On average, for each 10 man-days of labor and 1 tractor-hour it was possible to remove over 70 cubic meters of sediment. Given that most sediment has to be manually lifted at least 1 m it is clear that people really did work extremely hard.

Hydraulic Impact of Desilting

Before desilting the average deliver performance ratio (DPR) at the head of the eleven canals was 1.29 (i.e. 29% above design), ranging from 213% of design at Bareji which had been remodeled in 1995 and could cope with much larger than designed discharge to 58% of design at Bagi. However, the DPR at the head of the tail sections averaged only 97% of design indicating that in most canals all of the extra water was being captured by the head and middle sections of the canal (Table 4).

Looking at the ratio between head and tail DPR values the degree of inequity can be clearly seen. In only two canals (Potho and Bagi) were tail end DPR values higher than the head: in all other canals head end values were higher than tail end and on averaged were 68% higher. At Heran and Belharo head end values were over three times as high as tail end values, showing gross inequity between head and tail.

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.

Table 4. Hydraulic Condition of the 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	1.02	1.28	**0.79**	0.74	0.98	**0.76**
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**
Average	**1.29**	**0.97**	**1.68**	**1.20**	**1.20**	**1.14**

CONCERNS FOR THE FUTURE

It would, however, be unwise to be complacent about the situation that was measured and observed during the January 2000 maintenance period. A number of issues remain that continue to cast doubt on the ability of Farmer Organizations to maintain their facilities now that management transfer has occurred.

Even on those canals where IWMI had undertaken physical surveys of cross-sections and longitudinal sections desilting remained more a matter of eyeballing than of systematic and controlled establishment of design sections. Yet at no time were physical measurements taken to determine whether widths, depth or slopes were consistent with what should be required to provide effective water levels at each outlet when the canal operates at design discharge.

Although hydraulic conditions improved in most canals, these results did not become incorporated into the daily actions of water users or the Irrigation Department, instead remaining more or less as a separate and unrelated measurement exercise. So the link between maintenance and performance remains weak or non-existent, and there is no sign of any major effort to try to link them again.

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 pilot project 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.

CONCLUSIONS

In systems with a high degree of control over water there is some opportunity for a trade-off between operation and maintenance in order to achieve the desired water distribution pattern. In the supply-based systems of the Indus Basin and northwest India this option is not available: if canals are not maintained so that their physical condition approximates the original design, it is impossible to achieve a reasonable degree of equity of water distribution.

Irrespective of who is given operation and maintenance responsibility, be it the Irrigation Department, Farmer Organizations or private companies, the basic maintenance requirements remain the same in these supply-based systems. If ownership or management responsibility changes, there is no hydraulic basis for altering the rules of operation and maintenance unless there is a change in design.

There is no shortage of available advice on how to operate and maintain irrigation canals, either at the general level through maintenance manuals, or through specific procedures laid down in manuals of the different Irrigation Departments. These procedures are available to all parties and there is no technical reason why any particular organization cannot implement them.

There is also no shortage of information on performance parameters, their values and tolerances, that should form the basis of an integrated operation and maintenance program that achieves the desired levels of water distribution equity and predictability that are the hallmarks of a well-managed supply-based irrigation system.

We therefore have to conclude the poor or inappropriate maintenance remains essentially an institutional problem. It is not that the technical knowledge does not exist, it is that people choose not to follow the technical advice. While accepting to some extent this may reflect poor financing of irrigation services, it seems much more a managerial and motivational matter. If performance is not part of the accountability process, then maintenance will not be done effectively.

In this context, improvements will not come because of improved manuals or greater attention to asset management. It has to come through recognition of the need for defined levels of service at each point where water transfers from one organization or group of people to another. If people believe in a level of service as the ultimate objective of an irrigation system, then it will be incumbent upon managers at each level to do whatever is necessary to accomplish that level of service. In the Pakistan context, with large supply-based systems with little opportunity for operational intervention, maintenance will continue to be the key

to delivering levels of service that meet the needs and aspirations of all members of the water using community.

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