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PERFORMANCE ASSESSMENT OF LINED WATERCOURSES IN DISTRICT JHANG

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Most of the on-farm water management problems were not new. These problems have grown larger and there was increasing public demand for the development and management of land and water to be ecologically sustainable as well as economically. Pakistan's agriculture totally depends on irrigation and irrigated land provides more than 90% of agricultural production. Due to the limited prospects for expanding irrigation facilities, the projected increase in irrigated agriculture had to come from significant improvements in the performance of existing systems. In Pakistan watercourse lining up to tail had been very limited due to high cost. This study was carried out to evaluate the impact of lining on four watercourses which were lined under National Program for Improvement of Watercourses (NPIW) project at the distributaries of Sultan Pakhra, Dhular, Bhangi and 3-L in District Jhang. The water conveyance efficiency and annual water savings in relation to increase cropping intensity and crop yield due to improvement of watercourses were studied. It was found that the conveyance efficiency of lined watercourse sections ranged from 83% to 90% whereas for unlined watercourse sections ranged from 36% to 69%. The average losses per 100 meter length in lined portion of watercourse from 0.3-0.6 and 1.0-2.0 lps in unlined portion. The cropping intensity of the selected sites increased 17-19% after lining. Crop yield was increased on an average of 530 kg/ha for wheat, 9600 kg/ha for sugarcane, 230 kg/ha for cotton and 190 kg/ha for maize after the lining of watercourses. The study was helpful for additional lining of the watercourses, motivation of farmers and performance improvements of the watercourses at the selected distributaries.

Keywords: Watercourse, lining, impact assessment, irrigation

INTRODUCTION

Water is one of the basic necessities of any living organism. It covers nearly three fourth of the earth's surface. The survival of plants normally depends upon the factors like soil, air, light and water. In areas where consumptive use of crops exceeds natural precipitation, supplemental irrigation is essential to replenish the soil moisture deficit for successful crop production. Pakistan with population of about 180 million is the largest single irrigated region in the world. The total geographical area of Pakistan is 79.61 million hectare (Mha). Out of 15.7 Mha of fertile soil, 9.3 mha are irrigated by an extensive system of feeder canals (Alam, 2002). The canal irrigation system, especially, the tertiary system is facing a number of operational problems resulting in very high degree of losses of water during its conveyance. The lining of irrigation channels help to conserve water and move water more efficiently. It reduces seepage, which prevents the loss of water from the system. The loss of water is not only economically undesirable, but it would seep on to adjacent land adding detrimental effect. Lining is a long term effective technique for reducing seeping losses from the watercourse, but on account of being costly; it is somehow provided only on 15-30% length at the head of watercourse (OFWM, 2005). Lining has increased 25% conveyance efficiency and if we lined all other watercourses not only conveyance efficiency will be improved but will also help in equal water distribution among farmers and will increase the command area of that watercourse (Arshad and Ahmad, 2011). It was absorbed that for the lined watercourses, the irrigation water losses ranged from 35 to 52 % and for the unlined these were from 64 to 68 % (Arshad *et al.,* 2009a).

The conveyance losses had a remarkable effect on water distribution; as conveyance losses at the head sections were reduced, farmers were getting more discharge at their farm gates (Sarwar *et al.,* 2001). It can be concluded that frequent maintenance and cleaning of earthen watercourses was necessary to maintain high conveyance efficiencies. Efficient water saving can be achieved by keeping the conveyance losses to a minimum level. The seepage quantities from unlined irrigation channels as quoted from various technical sources ranges from 25% to 50% of transported water (Shahid *et al.,* 1996).

WAPDA (2004) undertook a water management research project at the Mona Reclamation Experiment Project (MREP) which determined that watercourse conveyance loss rate ranged from 31% to 57%, with the highest losses in SCARP areas.

The OFWM program had developed as a technical approach for water conservation and its improved management at watercourse command level, OFWM program were now told recognized and enthusiastically supported by the farming community. A majority 86.5 percent of the farmers perceived that there was great improvement occurred in water delivery efficiency through watercourse renovation (Siyal, 2007).

The issue of water losses through irrigation systems had a major impact on surface water supplies and management. Although a number of national and international organizations had attempted to assess the degree of losses from the watercourses, the impact of lining on the same command on the water losses had not been addressed (Arshad *et al.,* 2009b).

This paper represents the aim to assess benefits from the lining to enhance cropping intensity and to increase crop yield for food security, and water savings to fight against water scarcity problem for sustainable agriculture.

MATERIALS AND METHODS

The study was conducted in District Jhang, which stands in the rolling flat plains of Northeast Punjab, lies between 30° 37′ to 31° 59′ North latitudes and 71° 37′ to 73° 13′ East longitudes. District Jhang is spread over an area of 8809 square kilometers having a population of 3.5 million with a density of 321.8 per square kilometers and comprises three tehsils, i.e. Jhang, Shorkot and Ahmed Pur Sial. About 85% of cultivable land is irrigated and wheat and cotton are the main crops. Other crops grown include rice, sugarcane, corn (maize), oilseeds, fruits, and vegetables. The soil of district Jhang is coarse (sand and loamy sand). The climate of study area is arid to semi-arid with maximum temperature of about 50°C and minimum temperature falls sometimes below freezing point.

The impact of lining of five selected watercourses of Sultan Pakhra, Dhular, Bhangi and 3-L distributaries in district Jhang was evaluated as shown in Table 1.

The water conveyance efficiency was calculated by measuring discharge of selected watercourses with the help of current meter at head, middle, and tail. The water saving was calculated from discharge data analysis in relation to increase cropping intensity and crop yield by conducting interview from farmers. The command areas of selected watercourses were different in nature in terms of length, design, discharge, gross command area (GCA), culturable command area (CCA), relative elevation, cropping pattern, cropping intensity, crop yield etc. Following steps were adopted for the completion of above objectives:

- Selection of one watercourse on each distributary improved under National Program for Improvement of Watercourses (NPIW) project for appropriate data collection.
- Each watercourse was divided into three portions as head, middle and tail.
- Measurement of velocity was carried out with the help of current meter at head, middle and tail of each watercourse.
- Measurement of cross-sectional area of each watercourse at head, middle and tail of each watercourse where the cross-sectional area of unlined portion was measured with the help of a cross-section with size 1.5m×1m.
- Determination of the discharge in selected improved watercourses by using velocity area method.
- Measurement of conveyance losses in lined and unlined portions of watercourses.
- The reach wise conveyance losses for lined and unlined section were determined using the following formula.

$$Q_L = \frac{(Q_i - Q_o)}{Q_i} \times 100$$

Where;

Q_L = Conveyance loss (%)
Q_i = Inflow rate (lps)
Q_o = Outflow rate (lps)

- Conveyance efficiency for lined and unlined sections of selected watercourses was calculated by the formula given below:

$$\eta = \frac{Q_o}{Q_i} \times 100$$

- Calculation of water saving per annum from discharge data analysis.
- Conducting the interviews of farmers for input and data

Table 1. Salient features of selected watercourses

Sr. No.	Name of distributary	Watercourse No.	Gross command area (ha)	Designed discharge (lps)	Total length (m)	Lined length (m)	Unlined length (m)
1	Sultan Pakhra	131322/L	305	110	3450	690	2760
2	Dhular	190585/R	400	19.25	6537	839	5698
3	Bhangi	23934-TL	789	150	4250	858	3392
4	3-L	21445/R	291	37	2544	320	2224
5	3-L	24958/R	322	52	3738	490	3248

of crops for the purpose of cropping intensity, yield and patterns.

- Selection of farmers at head, middle and tail of each watercourse
- Preparation of questionnaire for interview of farmers.
- Collection of input data of crops before and after improvement of watercourse.

RESULTS AND DISCUSSION

***Conveyance losses*:** Conveyance losses in lined and unlined sections of five watercourses located at the head, middle and tail reaches of the different five distributaries are shown in Table 2 and 3, which shows that the conveyance losses were lower in the head to middle sections, whereas there were higher in the middle to the tail sections.

The middle to tail section was totally unlined that is why there were higher conveyance losses in that portion of watercourse. Other factors like watercourse maintenance, length and amount of discharge available in the watercourse also affected the conveyance losses. The conveyance losses in the head to middle sections, mostly lined, of the sample watercourse ranged from 5% to 20% whereas the conveyance losses in the middle to the tail sections ranged from 25% to 70%.

***Conveyance efficiency*:** Using the flow rate of the lined and unlined portions of the watercourses (at inlet and outlet), the conveyance efficiencies computed are shown in Figure 1. The results reveal that the average conveyance efficiency in the lined watercourse was 88%, while the conveyance efficiency in the unlined portion of the watercourses was 52%. The reason of the less conveyance efficiency in unlined portion of the watercourses was absolutely due to lack of proper maintenance of the watercourses hence more seepage and leakage losses presence of vegetation, improper alignment of the watercourses and rodent effect.

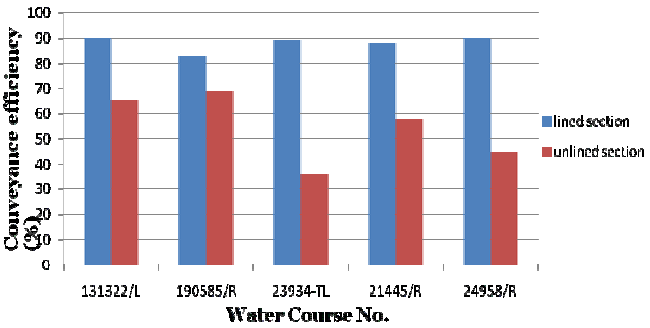

Figure 1: Average conveyance efficiency of lined and unlined portion of watercourses

Table 2. Reach wise conveyance losses in lined section of watercourse

Date	lined length (m)	Discharge at inlet (lps)	Discharge at outlet (lps)	Losses (lps)	Water loss (%)
Watercourse No. 131322/L	690				
09/10/2010		115	104	11	10
18/10/2010		99	90	9	9
27/10/2010		126	109	17	13
05/11/2010		99	87	12	9
Watercourse No. 190585/R	839				
09/10/2010		26	22	4	15
18/10/2010		19	16	3	16
27/10/2010		25	20	5	20
05/11/2010		22	18	4	18
Watercourse No. 23934-TL	858				
17/09/2010		163	142	21	12
24/09/2010		147	124	23	16
01/10/2010		154	140	14	9
08/10/2010		136	122	14	10
Watercourse No. 21445/R	320				
26/08/2010		46	44	2	11
04/09/2010		39	33	6	8
12/09/2010		41	37	4	9
20/09/2010		34	29	5	14
Watercourse No. 24958/R	490				
26/08/2010		65	59	6	9
04/09/2010		43	38	5	11
12/09/2010		59	54	5	8
20/09/2010		53	46	7	13

Table 3. Reach wise conveyance losses in unlined section of watercourses

Date	Unlined length (m)	Discharge at Inlet (lps)	Discharge at outlet (lps)	Losses Qi – Qo (lps)	Water loss (%)
Watercourse No. 131322/L	2760				
09/10/2010		104	65	39	38
18/10/2010		90	60	30	33
27/10/2010		109	69	40	37
05/11/2010		87	58	29	33
Watercourse No. 190585/R	5698				
09/10/2010		22	15	7	32
18/10/2010		16	11	5	31
27/10/2010		20	14	6	30
05/11/2010		18	12	6	33
Watercourse No. 23934-TL	3392				
17/09/2010		142	52	90	63
24/09/2010		124	42	82	65
01/10/2010		140	48	92	66
08/10/2010		122	38	84	69
Watercourse No. 21445/R	2224				
26/08/2010		44	22	22	46
04/09/2010		33	18	15	45
12/09/2010		37	22	15	40
20/09/2010		29	18	11	37
Watercourse No. 24958/R	3248				
26/08/2010		59	26	33	55
04/09/2010		38	18	20	52
12/09/2010		54	24	30	55
20/09/2010		46	19	27	58

Table 4. Percent reduction in conveyance losses per 100 m length in lined/ unlined portions in improved watercourse

Watercourse No.	Average losses per 100 m in lined portion of improved watercourse (lps)	Average losses per 100 m in unlined portion of improved watercourse (lps)	Reduction in losses per 100 m length (lps)	Percent Reduction in losses
131322/L	0.353	1.00	0.647	64.7
190585/R	0.0625	0.0925	0.03	32.4
23934-TL	0.423	2.045	1.622	79.3
21445/R	0.165	0.628	0.463	73.7
24958/R	0.153	0.975	0.822	84.3

***Water saving*:** The average losses per 100 meter length in lined portion of watercourse ranged from 0.3-0.6 lps and 1-2 lps in unlined portion, as shown in Table 4. The average reduction in losses per 100 m length of watercourse was 66.9%.

***Cropping pattern*:** The cropping pattern of the watercourses under study for the Rabi and Kharif seasons for the cropping year 2008-2009 was assessed through designed questionnaire. The data collected revealed that there was no significant change in the cropping pattern. The farmers were invariably growing the same crops, which they grew before the improvement of the watercourses, despite the fact; the improvement of each sample watercourse to save a considerably quantity of water per annum. The lack of marketing and storage facilities remained hurdle for farmers to grow other crops such as fruits and different vegetables.

***Cropping intensity*:** The data regarding cropping intensity of five watercourses under study for both seasons before and after improvement of watercourse are shown in Table 5. It is evident from Table 5 that annual cropping intensity of watercourses located at the head of the Sultan Pakhra and Dhular minor before lining are 125 and 146 % respectively and after lining are recorded as 156 and 175 % respectively. Thus there was an increase of 17 and 20% in cropping intensities with the lining of watercourses. Likewise annual cropping intensity of the watercourses located at the middle reach of the distributaries had gone up from 104% and 116% (before lining) to 123% and 134% (after lining) indicating an

Table 5. Reach-wise annual cropping intensity of selected watercourses

Reach	W/C No.	Rabi (2008-2009)		Kharif (2009)		Annual (2008-2009)		Increased (%)
		Before lining	After lining	Before lining	After lining	Before lining	After lining	
Head	131322/L	65	76	50	61	125	156	17.9
Head	190585/R	78	89	62	78	146	175	18.6
Tail	23934-TL	70	77	24	30	95	108	14.5
Middle	21445/R	54	63	47	55	104	123	18.7
Middle	24958/R	64	77	57	71	116	134	17.1

increase of 16 and 18% in cropping intensities respectively. Similarly, the annual cropping intensity for the watercourse located at the tail of the Bhangi distributary can be seen as 95% and 108% before and after improvement respectively, showing an increase of 14%.

The annual cropping intensity in the reach before lining was 3%, 39% and 26%, 50% more than that in middle and tail reaches respectively. Similarly, after improvement the cropping intensity in head reaches was 4%, 46% and 34%, 60% more than that in the middle and tail reaches respectively, which can be attributed water saving achieved due to lining.

***Crop yield*:** The yield data in kg/ha of major crops grown in the command area of five watercourses selected for study are portrayed in Figure 2. Crop yield was increased on an average of 530 kg/ha for wheat, 9600 kg/ha for sugarcane, 230 kg/ha for cotton and 190 kg/ha for maize after the lining of watercourses.

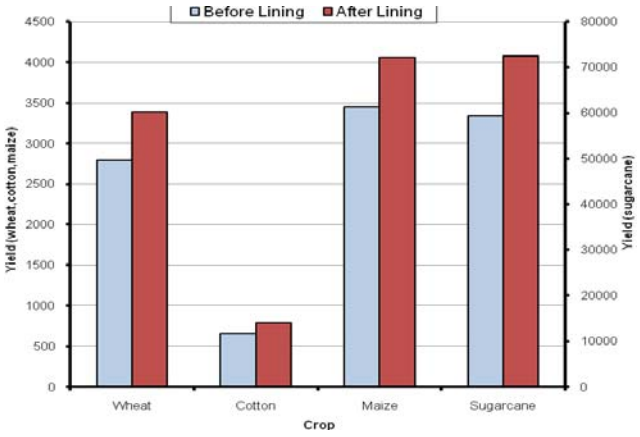

Figure 2: Average yields of major crops grown on the command of watercourses

CONCLUSIONS

Lining of watercourses significantly increased the water conveyance efficiency and thus reduced water losses through watercourses. The conveyance losses were comparatively lower in the head to middle portions due to lined watercourse portions whereas significantly higher conveyance losses were found in the middle to the tail portions due to unlined watercourse portions.

The water saving within the watercourse was highly affected by the losses in watercourses due to outlet structure and the water level in the distributary. No change was observed in cropping pattern due to lining. The cropping intensity at the command area of watercourses was increased by about 40% in Rabi and 55% in kharif seasons due to lining.

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