ECONOMIC FEASIBILITYOF WATERCOURSES LINING IN SINDH PAKISTAN

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ABSTRACT:*Economic feasibility of watercourse lining covering the entire area of its command is very necessary as it has been adopted to accomplish certain objectives that should reflect in the form of resultant benefit and prosperity of an area. The lining of watercourses has to leave a positive reflection in a sense of water saving. This study was carried out on three lined watercourses selected on Mureed minor in Jamrao canal command. The water conveyance efficiency, annual water saving, increase in cropping intensities were studied. Water saving through 30% lining of initial portion of watercourses was obtained as 6.5 ha-m which could be utilized to cultivate an additional land of 7hectares. The cropping intensity has increased by about 29 % in Rabi and 12 % in Kharif seasons. Crop yield increased by 16 % for wheat crop, 27% for cotton crop, 11%for sugar cane, 27% for chilies, and 19% for onion crop after lining the watercourses.The water table in the command area of the watercourses under study has gone down by 1 m after lining. Thus water logging problem has been minimized to some extent. The benefit cost ratio of the project is worked out as 2.06 which is much more than unity which clearly indicates that the project is economically feasible and viable.*

Key Words: Cropping intensity, water saving, conveyance efficiency, watertable

INTRODUCTION

Scientific management of irrigation water provides the best insurance against weather-induced fluctuations in total food production. This is the only way in which we can make our agriculture competitive and profitable. An integrated policy for water resources management, in addition to efficient utilization of the resources for optimum crop production, should meet the requirements of the growing industry, human and livestock consumption, and provide for flood control, hydroelectric power, recreation and navigation.

The agricultural production especially water productivity in the country is relatively low as compared to the other countries having similar climate, land and water recourses. One of the major constrains responsible for low production is due to substantial loss of water in conveyance system. Therefore, there is a need to adopt improved irrigation techniques to minimize losses and utilize the saved water for maximum crop production. Furthermore, greater attention is required to the On Farm Water Management to avoid under and over irrigation which causes water losses, low crop production and salinity on one hand and water logging on the other hand.

Irrigated agriculture in the country require further improvement of existing methods and practices for increasing crop production and conserving energy and water. The growing demand for water resources emphasizes the need for improved design and management strategies for the dwindling water resources to ensure high water productivity.

The loss of this valuable water cannot be tolerated. Lining of an irrigation canal is justified economically when its cost can be repaid in terms of benefits derived during the life of the lining. Some of the most important tangible benefits resulting from lining irrigation canals those that can be evaluated with some accuracy are water saving that would otherwise be lost though seepage, reclamation of water logged lands, lower maintenance and economies of canal lining operational cost [1].

In order to minimize the conveyance losses and to improve irrigation efficiency, government has taken substantial steps. In this regard On-Farm Water Management projects have been launched throughout the country to save the considerable quantum of water. In these projects watercourses, minors and distributaries have been lined. Besides, land leveling has also ensured the uniform distribution of water over the field and reduced the field application losses.Therefore the evaluation of water saving as stated by [2] is of utmost importance to check the viability of the project work.

Economic evaluation

Any project implemented by an agency has some objectives. The achievement of objectives is of prime importance. Alternatively the achievements of objectives leave some impact which must be the resultant of these objectives in shape or form of benefits. Economic Evaluation through the assessment of these benefits plays very important role in devising and facilitating the future strategies based on the benefits acquired from the project. Sometimes this assessment is periodically and several things are to be incorporated in the projects for getting more possible benefits in due time for what it is designed for

The impact assessment is the assessment of overall project performance in terms of achieving its objectives on predetermined project performance criteria and translating them in to oriented qualitative and quantitative key indicators on the subject under study.

Here the term assessment of impact of watercourse lining covering the entire area of its command is very necessary as it has been adopted to accomplish certain objectives that

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Table 1. Salient features of watercourses

Name of water course	C.C.A (hectare)	Design discharge m^3s^{-1}	Total length (km)	Lined length (km)	Unlined length (km)
162/3A	144	0.15	2.82	0.846	1.97
171/1R	307	0.24	6.39	1.91	4.48
184/5T	141	0.083	2.34	0.70	1.64

should reflect in the form of resultant benefit and prosperity of an area. The lining of watercourses has to leave a positive reflection in a sense of water saving which could be the only tool to enhance the cropping intensity, improve cropping pattern to ensure the food security for people.

Economic feasibility

Expenditure on a project is justified if the resultant annual benefits realized from the project exceed the annual costs (including interest on the capital expenditure). i.e, benefit-cost ratio (BC ratio) is more than one [3]. This factor is yard stick to check the economic feasibility of the project.

MATERIAL AND METHODS

For the purpose of study, Mureed Distributary was selected. It consists of 26 watercourses and is designed to irrigate a command area of 3977 hectares. For carrying out economic evaluation & feasibility study of lining, three watercourses were randomly selected on the head; middle and tail reach of the distributary. Each watercourse was divided into three portions as head, middle, and tail. Salient features of sample watercourses are shown in Table 1

Discharge measurement

The discharge measurement is an important task and requires very care to find out the exact quantity of water flowing in the system. In this study the discharges at the required potions of the unlined watercourses were measured with help of cut throat flumes (size 8"x 3' and 12"x 3' having discharge capacity of 0.0283 to 0.077 m^3s^{-1} and 0.085 to 0.22 m^3s^{-1}). The method was adopted as described by [4]. Whereas the discharge in lined portion of watercourses were measured through current meter as described by [5].

Conveyance losses

In order to estimate water losses and conveyance efficiency in lined and unlined section of watercourses the inflow and outflow method was used. For this, watercourse length was divided into two portions. First portion comprised lined section where as second portion was unlined. Three cut-throat flumes were installed at sections A, B, and C. Thus the difference of discharges at section A and B gave conveyance loss in the lined portion. The difference of discharges at section B and C gave conveyance loss in unlined portion of the watercourse. Conveyance losses were estimated by following formula [6];

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

Where,

Q_L = Conveyance losses (%)
Q_i = Inflow rate (m^3s^{-1})
Q_o = Out flow rate (m^3s^{-1})

Conveyance Efficiency

It is the ratio of the water delivered into the field from the outlet point of the channel (Nucca), to the supplied to the channel at the starting point of module. It was calculated by the following equation [7];

$$\eta_C = \frac{Q_d}{Q_s} \times 100$$

Where

η_c =Conveyance efficiency (%)
Q_d = Water delivered at the field (cumec)
Q_s = Water supplied at mogha (cumec)

Annual water saving

Keeping in view the reduction in magnitude of conveyance loss due to lining, the saving were estimated by deducting the percentage of conveyance loss due to lining from otherwise the conveyance loss observed in unlined portion. Assuming 330 operational days annually for the conveyance system, the saving was then reflected to only 30 % of lined portion by dividing the total saving with 3 (30 % of total watercourse length was lined). Assuming 75% irrigation efficiency, the net saving was obtained. As a general rule 1m is required annually for one 0.44 hectare, thus the area to be cultivated from saved water can also be estimated.

Crop data through questionnaire

Selection of respondent for questioner

The data was collected by interviewing the landowners located on the head, middle and tail reach of sample watercourse according to the plan made for the comparison of the events reach wise before and after lining. The interviews were conducted from the farmers having different size of farms from small to big farmers. This practice supported the data to be in the limits of accepted deviation.

Cropping intensity and pattern

To assess the cropping intensity and cropping pattern, a field survey was carried out through questionnaire from the farmers in the command of watercourses. The data recorded on recall basis comprise of the area under different crops by each farmer before and after the lining of watercourses for the crop season 2013-2014.

Crop yield

The data regarding the yield of major crops was also collected from farmers of the study area through questioner on sample basis. Then the data was statistically analyzed to assess the yields of crop for pre and post lining of watercourses under the study.

Process of data analysis

The information in the questioner was put into the EXEL to make a comprehensive analysis of the data that the perception

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

WC No	Location of w/c	Lined length (km)	Discharge inlet (m^3s^{-1})	Discharge outlet (m^3s^{-1})	Loss %	Conveyance loss % per km
162/3A	Head	0.846	0.148	0.145	2	2.36
171/1R	Middle	1.91	0.235	0.225	4	2.09
184/5T	Tail	0.70	0.083	0.081	2	2.85

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

WC No	Location of w/c	Unlined length (km)	Discharge inlet (m^3/sec)	Discharge outlet (m^3/sec)	Loss %	Conveyance loss % per km
162/3A	Head	1.974	0.145	0.130	10	5.06
171/1R	Middle	4.474	0.225	0.198	12	2.68
184/5T	Tail	1.638	0.081	0.072	10	6.10

of farmers related to the specific objectives could easily be captured. The data was analyzed for pre and post lining conditions of watercourses for different parameters such as: conveyance losses, cropping pattern, cropping intensity, and extent of water logged condition.

Extent of water logging

The information regarding the watertable status reflecting water logging in the command of sample watercourses was collected through questioner. Besides this; the command area under the study was physically visited by walk through survey to support the data collected through questioner particularly in the case of water logging scenario after lining the watercourse.

Economical feasibility

Annual benefits achieved through lining

The main benefit from lining is water saving and the net income earned from the area irrigated for that saving. The other benefit includes saving in maintenance. To evaluate these tangible benefits from the area cultivated on saved water, farmers were interviewed to retrieve the information about overall cost of production per hectare and overall net benefits received per hectare. Thus, total annual benefits were estimated.

Annual cost of lining

The costs of lining for the life of lined potion of watercourses have been collected from department of Sindh On Farm Water Management (SOFWM). The expected life of watercourses lining was assumed as 15 years. Then annual cost of lining was worked out.

Benefit cost ratio

Benefit cost ratio is considered as criterion to compare the economic feasibility of same enterprises at different sites with different combination of inputs. The benefit cost ratio was calculated from the formula;

$$Benefit\ Cost\ Ratio = \frac{Annual\ Benefits}{Annual\ Cost\ incurred}$$

If benefit cost ratio exceed unity, the activity / project is rated as feasible

RESULTS AND DISCUSSION

Conveyance losses

Conveyance losses in lined sections of three water courses located at the head, middle and tail reaches of the Mureed distributary are shown in Table 2. The losses observed are in the order of 2%, 4 % and 2 % respectively. These losses were observed to occur due to leakage through nuccas which were improperly installed and also due to natural phenomena of evaporation. Seepage was also visible from rectangular bricks watercourse due to improper filling of vertical joints (inter brick spacing) in brick masonry work. It is also obvious from Table 3, that the conveyance losses in unlined portion of three watercourses located at the head, middle and tail of distributary are 10%, 12% and 10% respectively. The results are also in agreement with [8] and [9]. These losses occurred mainly due to seepage through bed & banks of watercourse and evaporation losses. These losses have negative impacts in terms raising watertable inversely as indicated by [10].

.**Conveyance efficiency**

Using the flow rate of the lined and unlined portions of watercourses (at inlet and outlet), the conveyance efficiencies computed are shown in Table 4. The results reveal that the average conveyance efficiency in lined watercourses is 97%, while the conveyance efficiency in unlined watercourses is 89%. The reason of less conveyance efficiency in unlined portion of watercourses is absolutely due to lack of proper maintenance of the watercourses, presence of vegetation, improper alignment of watercourses and rodent effect. Thus the conveyance efficiency has improved by 8 % due to the lining of the watercourses.

Water saving

The estimation of water saving isportrayedin Table 5. The saving has been calculated byavertingthe loss due to lining. The proportion of loss occurring in lined section is subtracted

from the corresponding loss of otherwise unlined section to get saving. Through lining of watercourse 14.13 ha.m water has been saved annually and from this quantity 7 ha more land can be cultivated annually.

Table 4.Conveyance efficiency in lined & unlined sections of watercourses

Water Course No.	Conveyance Efficiency in lined section	Conveyance Efficiency Unlined section (%)
162/A3A	97.8	89.7
171/1R	95.9	87.9
184/5T	97.9	89.8

Table 5. Status of water quantum before and after lining

W/C No.	Status of Water Before Lining				Status of Water After Lining				Av: saving ha.m
	Inlet (Q_i) m^3/sec	Outlet (Qo) m^3/sec	Q_L %	Annual Loss ha.m	Inlet (Q_i) m^3/sec	Outlet (Qo) m^3/sec	Q_L %	Annual Loss ha.m	
162/3A	0.145	0.141	10	42.70	0.149	0.145	2	31.23	
71/1R	0.226	0.198	12	78.24	0.236	0.226	4	58.23	14.13
184/5T	0.081	0.073	10	24.19	0.083	0.081	2	13.27	

Table 6.Reach-wise annual cropping intensity of Sample Watercourses

Reach	**W/C NO.**	**Rabi 2013-2014**		**Kharif 2014**		**Annual 2013 -2014**		**Increase %**
		Before lining	**After lining**	**Before lining**	**After lining**	**Before lining**	**After lining**	
Middle	162A/3A	61	76	49	59	110	135	25
Middle	171/1R	59	67	48	56	107	123	16
Tail	184/5T	39	45	33	36	72	81	09

Cropping pattern

The data on cropping pattern of the watercourse selected reveals that was no significant changes in the cropping pattern before and after lining. The farmers were invariably growing the same crops which they did before the improvement of the watercourses despite the fact that the improvement of each sample watercourse has helped to save a considerable quantity of water per annum.

Cropping intensity

The data regarding cropping intensity of three watercourses under study for both seasons are shown in Table 6 shows that the annual cropping intensities of watercourse located at the head of Mureed distributary before lining was 110% and same after lining was recorded as 135%. Thus there is a change of 25% in cropping intensity. Likewise show the annual cropping intensity of the watercourse located at the middle reach of the distributary before lining and after lining. It can be seen from the Tables that annual cropping intensity was 107 % before lining and 123 % after lining. Thus there is an increase of 16 % in cropping intensity. Similarly, the annual cropping intensity in the command of watercourse located at the tail of the distributary during Rabi and Kharif is given in Table 6. The data reveals that annual cropping intensity was 72% before lining and 81 % after lining which shows increase of 9%.

On overall basis, the cropping intensity in head reach before lining was 2% and 38% more than that in middle and tail reaches respectively. Similarly, cropping intensity in head reach after lining is 4 % and 46 % more than that in middle and tail reaches respectively

Crop yield

The yield data of major crops grown on the command of three watercourses selected for study areportrayed in Tabl 7. It is obvious from the data there the crop yield increased by 16 % for wheat crop, 27% for cotton crop, 11% for sugarcane, 27% for chilies and 19% for onion crop after lining the watercourse. This increase in yield is not absolutely due to lining but also many other factors has also have impact on it.

Extent of waterlogging

The data pertaining to water table position in the command of watercourses under study is presented in Table 8. Data indicates the water table has dropped by 0.91 m , 0.61 m and

Table 7.Yields of major crops grown on the command of watercourses

Crops	*Before lining (kg/ha)*	*After lining (kg/ha)*	*Average increase (kg/ha)*	*Increase (%)*
Wheat	3162	3656	494	16
Cotton	2174	2766	593	27
Chilies	2174	2766	593	27
Sugar cane	74100	82004	7904	11
Onion	17784	21242	3458	19

Table 8.Extent of water logging in the command of watercourses under study.

Reach	W/c No	Watertable level Before Lining (m)	Watertable level After Lining (m)	Improvement (m)
Middle	162A/3A	1.83	2.74	0.91
Middle	171/1R	1.83	2.44	0.61
Tail	184/5T	2.13	3.05	0.91
Average		1.83	2.74	0.91

0.91 m in head, middle and tail reaches respectively. On average, the drop in water table is about 1 m. This drop in water table elevation is attributed to lining of conveyance system in the area, better water management practices adopted by the growers of the area and less water in the irrigation network thereby less seepage.

Economic feasibility of the project

To assess the economic feasibility of three lined watercourses under study, the annual benefits have been quantified through field data in the manner as mentioned in the research conducted for lined irrigation canals by [11] and the cost incurred on the lining process has also been collected from offices of National Program for Improvement of Watercourses Project. The work sheet for benefits realized and cost incurred is given in Table 9

Table 9. Annual benefits achieved from lining

Average income from Kharif crops	= Rs 10,000/ha
Average income from Rabi crops	= Rs 17,000/ha
Average income generated from both seasons annul	= Rs 27,000/ha
Area cultivated on saved water	= 7 ha
Therefore, Total income generated due to lining	= 7 x 27,000 = Rs. 189,000/ year
Other benefits due to lining	= Rs 16,000 / year
Total benefits due to lining	= Rs. 205,000/year

Annual cost incurred on lining

Assuming lining life = 15 years
Average Lining Cost = Rs 1500,000.00
Therefore cost of lining per year = Rs. 100,000.00

Benefit cost ratio

$$Benefit\ Cost\ Ratio = \frac{Annual\ Benefits}{Annual\ Cost\ incurred}$$

$$= \frac{205{,}000}{100{,}000}$$

$$= 2.05$$

The B.C ratio is more the cost incurred on lining which indicates that the project is economically feasible and viable.

CONCLUSION

The improvement in conveyance efficiency of watercourses obtained was 8% by 30% lining of total length to save 14.13 ha-m to cultivate 7 hectares more land as cultivated before lining. The cropping intensity has increased by about 29 % in Rabi and 12 % in Kharif seasons. The cropping pattern assessed before and after watercourse improvement has remained almost same as no any proper marketing facilities were available for the land owners for growing other crops, vegetables and fruits. Crop yield increased by 16 % for wheat crop, 27% for cotton crop, 11% for sugar cane, 27% for chilies, and 19% for onion crop after lining the watercourses. On average the watertable in the command area of the watercourses under study has gone down by 1m after lining. Thus water logging problem has been minimized to some extent. The benefit cost ratio of the project is worked out as 2.06 this is much more than unity which clearly indicates that the project is economically feasible and viable.

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