Assesing Impact of Channel Lining for Water Management in Sindh

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Abstract— The cultivated area of 12.815 million acres of Sindh Province gets irrigation supplies for agriculture Purpose from Indus River through three barrage systems at Guddu, Sukkur and Kotri in the order of their locations. The availability of water is limited. The Seepage losses & theft of water occurs during the flow of Irrigation water through existing earthen channels. Seepage losses are up to 40% to 50% from earthen canals causing reduction in irrigation water supply in the canal command area of three Barrages. To reduce these losses and also to control proper water management to assure irrigation supplies at the tail ends, the canal lining of channels with cement concrete is the best way to resolve such issues. A study pertaining to the impact and assessment of canal lining in most agricultural productive area under lining project was conducted. To assess impact and benefits of lining, hydraulic, agriculture and Socio-economic indicators were used which included changes in cropping intensities, cropping patterns, increase in crop yield, The outcomes of the study reveal that lining of canals has positive impact and benefits on hydraulics of canal lining and agriculture & socio economics of the study area. The study results showed that the overall crop production has increased by 11.72-75.38% with the lining of Bilawal Zardari Minor District Shaheed Benazirabad Sindh and increase in CCA has been observed about15.96-73.25% with the lining of Said Khan Distributary District Matiari. Cropping intensity of land cultivating by Bilawal Zardari Minor and Said Khan Distributary has been increased by 23.22% and 17.0% respectively. No change in cropping pattern was observed. The quantum saved through lining due to reduction in losses was averagely 32.557(37%) and 37.638 cusecs (49%) which resulted in an increase in crop yield by 7,078 and 8,182 acres in Bilawal Zardari Minor and Said Khan Distributary respectively. Lining has increased conveyance efficiency and if well lined all other distributaries and minors 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 distributary/Minor.

Index Terms— Pre & Post-lined Distributary/Minor, Water losses, Conveyance Efficiency, Cropping Intensity, Socio-Economic Impact.

1 Introduction

THE world's single largest (Mega) irrigation system is known as the Indus Basin Irrigation System (IBIS) irrigating total land of 17.2 Million hectors. In addition to the main irrigation system having 44 canal commands and a large number of branches and distributaries, there are nearly 100,000 watercourses supplying water to the agricultural fields. There are remarkable water losses both in unlined canals, distributaries and from water courses.

Pakistan has generally dry climate with inadequate water resources. The cultivation/ agriculture region is the main user of water. River Indus water almost 97% is utilized for cultivation purpose but much of water is lost as seepage. Major cause of leakage/seepage loss from unlined canals is due to the poor rehabilitation of canal banks, which are not properly maintained as per design section. The water loss from canals is projected for different sets of precise circumstances [1].

Studies/Research of IDWR (2005) has revealed the delivery losses may be about 40% of water abounding to this arrangement. Government of Pakistan set huge hard work to save water on the water course & canal level schemes. Several projects have been undertaken in this track to get better deliverance of the irrigation system [2].

- Concrete Lining of Distributary & Minors in Sindh region, performance of the lining of unlined channels and water Management is the key focus of attention of this study (LDMSP).
- A new department has been launched for the betterment of water course & to reduce the seepage losses, the project of Command water management, on form water management and irrigation Department are working together on this project (OFWM).

In Pakistan, the current water loss is on near to 40% from old canal systems, a larger number of canals required to be lined. Country has about 17 Mha of cultivable field in the Indus region which is losing water and standard of 55% due to escape & succeeding water logging of cultivable lands. The worldwide avg. reliance / need of water for cultivation of land are required (.05 m hectare/million) but our need is 0.01 m hectare/ million populations which is double of it. Thus, Pakistan per capita loss of water is also double of world`s average rate through seepage & other losses, which is shocking and requires immediate attention to resolve the matter by controlling the seepage and other losses. The Government of Pakistan at this time is funding the viable this project of concrete lining of distributary & minors in Sindh region which is most valuable & economical solution for meeting the future demand of water, More than thirty five percent of the canal system or 13,000 miles of canals must have to be lined in future to face the water shortage issues [3]. The main purpose of channel lining project in the province of Sindh is to achieve the under mentioned benefits in the irrigation industry for efficient management of the water resources. The benefits are summarized below.

- To decrease the depletion of irrigation supply to Stakeholders.
- To curtail threats of twin problem of waterlogging & salinity which has adversely affected the irrigated agriculture land in the Sindh region.

- To curtail the seepage from canals/distributaries and water courses, from those specific areas which have brackish/high ground water-table, which is collapsed water los that can't be reused,
- Providing the physical growth to crop land by increasing the power of cropping pattern in study area by scrutiny of the seepage losses.

2 Literature Review

Survey conducted in Country show that around one portion of the water conveyed from canals to cultivate channels, doesn`t reaches the farmers /zamindars in' fields [4]. Loss of water in older earth channels enhanced exponentially as water levels raises in them because of development of vegetation & coming about increment in roughness coefficients. Loss increases around 9% & 12% /cm of water level increment in farm channels of Colorado & Pakistan, individually [5].The irrigation canal system of the Indus basin of our country is confronting various operational issues bringing about high level of losses of water amid transport of water system water to fertile lands. These water losses result in obliged water supplies of canal water in Indus Basin. Water losses from these channels affect surface water supplies & needs the better management, & should be limited, if not through and through wiped out. This is maybe the most financially savvy technique for expanding water supplies [2]. Out of complete canals withdrawals of 106.3 M.A.F., conveyance in the alluvial channels and distributaries are 21.5 M.A.F., whereas another 16.5 M.A.F water is lost through katcha water courses & ditches locally made trench. The significant piece of the conveyance loss for example 87.5% is said to be the seepage loss [6]. Lining of canals/distributaries is done to improve design hydraulic performance, operational effectiveness value of water distributaries & to lessen drainage. Be that as it may, there is requirement for building up the financial reasonability and supportability of lining, to set up how to line does without a doubt realize the anticipated advantages over the expected time frame [7]. The world's traditional of reliance on channel irrigation area is 0.05 m ha/millions of publics. It might, dependency of Asian country arranged canal irrigated area are (0.1 m ha/million) of public that is double the world's traditional. The overall irrigation effectiveness is assessed underneath 40% with greatest losses/seepage happening in the distributaries [8]. The water framework structure involves an arrangement of channels, distributaries, and field channels. Transport setbacks in the distributaries and field channels and around 25% and 30%, independently [9]. Past estimations of seepage loss from unlined channels demonstrated that the majority of the Loss happens through the upper segments of channel banks. It is assessed that the water system and the water availability to the field is 78 M.A.F out of 105 M.A.F of water diverted into the channel system. Everything considered 27 M.A.F is lost in the secondary level water system framework inferable from surface disappearing leakage from the unlined canals and the insufficiently kept up channel banks. The genuine Loss of 49 M.A.F occurs at tertiary/water course level as a result of the ineffectually kept up waterways, poor land-levelling and defective water system practice at the field level. Canal lining materials may have low seep age rates; possible cracks or poorly built joints can cause amazing seep age. In this manner, considerably under perfect conditions lining may decrease seep age just by 60% [10]. Experiment was conducted on 16 watercourses, which shows that water overflowing Losses from lined watercourses extended from eight to 19% of inflow. P.E.R.I determined that transport Losses rates on 1000 /m on the improved (earthen) & lined water course were thirty-two & thirty-nine, severally, that indicated a big distinction [11]. Onthe lined water courses a net increase of 12 to 14% within the conveyance efficiency was found through head to tail extent, Lining in water canals are additionally estimated toward extend production by economical utilization of resources, enhanced irrigation facilities, strong farmer's involvement in form of F.O within the managing of water, and customarily endorsed for the evolution of the agricultural land.

3 Research Methodology

An important part of the water entertained to irrigation canals is lost in seepage, the requirement for Lining channels in deposit has long been recognized to save equally of water for a lot of and more utilization, Lining of an irrigation channel is resorted to attain all or a number of objectives given below however additionally keep seeable the saving of the project.

- Reduction of seepage Losses leading to water saving which may be utilized for additional irrigation;
- Stoppage of water logging via decreasing, seepage toward water-table;
- Enhancement in discharge capability of standing channel;
- Improvement of operational efficiency;
- Prevention of preparation of weed growth; and
- Decrease in application of O & M cost.

The study was initiated in 2009 which has for assessing the speed of seepage Losses and its management when cc Lining, deciding improvement in water distribution, deciding water-table depth and economic advantage of the channel.

3.1 Data Collection and Study Area

The study was carried in respect of research & Social effects in two districts of Sindh i-e Shaheed Benazir Abad/Nawab shah and Matiari, the two channels randomly were selected from both districts for the analysis and evaluation of Data as per objectives given below.

1. Bilawal Zardai Minor — Nawabshah/SBA District
2. Said Khan Distributary — Matiari District

Main objectives of the study are:

- To evaluate the impact of lining on channel seepage losses before & after lining;
- To calculate the increase in Cultivatable Command Area (CCA), cropping intensity and saving in water quantum in the area under study;
- To evaluate socio-economic impact on the Living standards of farmer's community of medium size farms in the area under study.

Bilawal Zardari Minor is located on the left side of Rohri Canal and it off takes at R.D 615+000 L/S, the length of the channel is R.D 36.95 or approx. 7.39 canal miles. The Minor at

presently discharge of 86.0 cfs & has 30 outlets. The cultivable command area is approximately 9,816 acres. The land near the channel was whichever water-logged and on higher outline or abandoned by farmers. The channel is now lined & it is observed that about 7,078 acres are further may being cultivated with passage of time.

Said Khan Distributary is located on Right side of Rohri Canal off takes from Hyderabad branch at RD 53+000 length of channel is RD 52.5 approximately. 10.5 canal miles. The channel at present taking discharge of 76.34 cfs & 46 outlets. The cultivable facility area is approximately 16,596 acres. The land near the channel was whichever water-logged and on higher outline or abandoned by farmers. The channel is currently lined & it is observed that about 8,182 acres are further being cultivated with passage of time.

Seepage Loss Measurement was performed by Seepage meter method, To determine the Total Seepage Losses (Cfs per Million Sft) before Lining following Empirical formulae was adopted as,

$$[b + 2d\sqrt{1+Z^2}] \times \left[\frac{10 \times L}{10^6}\right] \quad (1)$$

Post Lining Seepage Losses were calculated for operation and maintenance from manual Sindh irrigation and drainage.

Empirical Formula for the Calculation of Seepage after Lining: To determine the Total Seepage losses (Cfs per Million Sft) after lining following Empirical formulae was adopted as, adopted,

$$[b + 2d\sqrt{1+Z^2}] \times \left[\frac{2\ XL}{10^6}\right] \quad (2)$$

Estimation of Water Use Effectiveness & Water Efficiency: Accounting where Losses arise at every stage as water moves from the canals to farms or cultivated land (accumulating Losses) &(transport Losses), applied to the farm (flow Losses), set aside in the soil (application Losses) and finally ate up by the yields (crop the officials Losses) for crop creation.

Describing the Area for Assessment: The information related to the change in water use efficiency is based on farmer's experience. It is clear from the results that Lining has positive impact on water use efficiency of the farms and there is overall increase is as given below in respect of percentage respectively, Interviews at middle reaches of Bilawal Zardari Minor and Said khan/Saidabad Distributary has been conducted for collecting information.

Socio-Economic Survey: A socio-economic survey was undertaken to provide socio-economic benefits related to the public areas of the project. The information collected by will focuses on: (i) household composition and demography;(ii) ethnicity; (iii) education; (iv) livelihood patterns and income baseline; (v) land ownership patterns; (vi) displaced persons income levels and expenditure patterns;(viii) displaced persons views on the subproject and various resettlement and rehabilitation options; (viii) specific impacts on the poor, including indigenous peoples, women and other groups of vulnerable. The all data were gender-separated to identify specific gender-linked issues. The research will be used to investigate the socioeconomic status of the population, identify project impacts on marginalized people and establish a monitoring marker and discharge pressure for subproject's compensation and reorganization.

4 Results & Discussions

From this study following results have been obtained considering objectives of the study area. The results were obtained regarding seepage Losses and different hydraulic parameters of the Bilawal Zardari Minor and Saeed khan distributary.

4.1 SEEPAGE LOSSES IN UNLINED & LINED SECTION:

To evaluate the impact of Lining on channel water Losses, seepage Losses before & after Lining of Bilawal Zardari Minor and Said Khan Distributary were recorded and depicted in Table 4.1 (a,b) and 4.2 (a,b) respectively.

Table 4.1 (a) : Calculation of Seepage Losses Before Lining of Bilawal Zardari Minor

N	0.022
Z	1.25

Earthen Reach Data/Before Lining					
Distance RD (ft)	To RD (ft)	Reach Length (ft)	Bed width (ft)	Depth (ft)	Total Losses (Cfs) Before Lining
					0.000
34+010	36+850	2+840	1.66	1.1	1.773
30+670	34+010	3+340	3.25	1.75	3.461
28+550	30+670	2+120	3.50	2.4	3.683
21+700	28+550	6+850	3.55	2.55	4.180
18+500	21+700	3+000	3.83	2.67	4.119
15+200	18+500	3+300	4.05	2.25	4.318
6+750	15+200	8+450	5.08	3.33	6.095
0+000	6+750	6+750	5.25	3.5	6.102
Total					33.73

Table 4.1 (b) : Calculation of Seepage Losses After Lining of Bilawal Zardari Minor

N	0.016
Z	1.5

Design Data/After Lining						
Distance RD (ft)	To RD (ft)	Reach Length (ft)	Outlets Group Discharge (Cusecs)	Design Bed Width (ft)	Computed Depth (ft)	Total Losses (Cfs) After Lining
34+010	36+850	2+840	15.16	3.50	1.71	0.051
29+670	34+010	4+340	7.11	4.50	2.01	0.095
28+620	29+670	1+050	7.11	5.50	2.19	0.026
24+030	28+620	4+590	8.96	6.50	2.4	0.130
18+540	24+030	5+490	11.65	7.50	2.65	0.176
13+540	18+540	5+000	8.63	8.00	2.84	0.171
10+140	13+540	3+400	8.00	8.50	2.9	0.121

6+700	10+140	3+440	9.36	9.00	3.07	0.130
0+000	6+700	6+700	5.93	10.00	3.23	0.273
Total						**1.172**

From Table 4.1(a) and (b) following results were obtained:

Total seepage Losses before Lining (Cusecs)	**33.729**
Total seepage Losses after Lining (Cusecs)	**1.172**
Saving of Discharge	**32.557**
Extra Land will be cultivated (Acres) as the discharge allowance on Rohri Canal is 4.6 cusecs / 1000acres	**7,078**

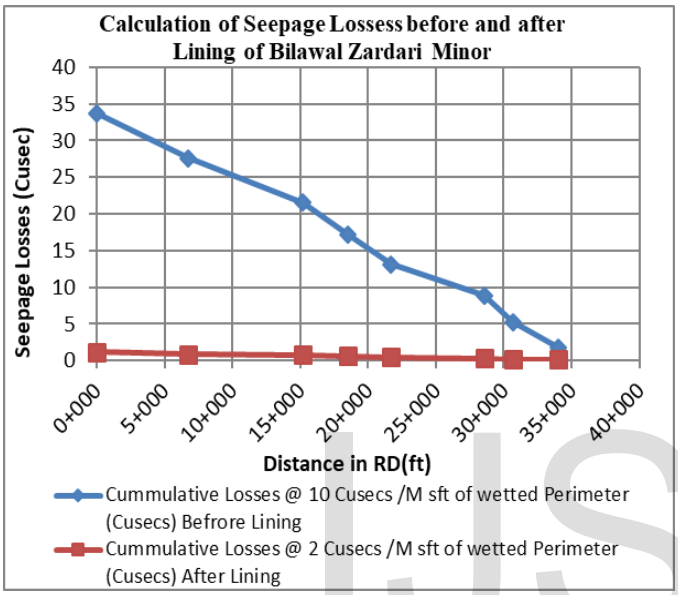

Fig. 4.1: Seepage Losses before and after Lining of Bilawal Zardari Minor

Table 4.2 (a) : Calculation of Seepage Losses Before Lining of Said Khan Distributary

N	0.022
Z	1.25

Earthen Reach Data/Before Lining					
Dis-tance RD (ft)	To RD (ft)	Reach Length (ft)	Bed width (ft)	Depth (ft)	Total Losses (Cfs) Before Lining
32+800	59+100	26+300	4.25	1.5	5.672
22+700	32+800	10+100	10.00	1.6	10.583
14+000	22+700	8+700	10.00	2.05	10.643
0+000	14+000	14+000	11.50	2.2	12.611
Total					**39.509**

Table 4.2 (b) : Calculation of Seepage Losses After Lining of Said Khan Distributary

N	0.016
Z	1.5

Design Data/After Lining						
Dis-tance RD (ft)	To RD (ft)	Reach Length (ft)	Group Dis. (Cu-secs)	Design Bed Width (ft)	Comp-uted Depth (ft)	Losses (Cfs) After Lining
48+500	52+500	4+000	10.39	2.00	2.09	0.070
40+500	48+500	8+000	10.00	3.00	2.26	0.164
31+950	40+500	8+550	9.16	4.50	2.36	0.206
26+700	31+950	5+250	24.78	7.00	4.27	0.217
14+100	26+700	12+600	9.91	8.00	4.38	0.555
0+000	14+100	14+100	10.90	9.00	4.5	0.660
Total						**1,872**

From Table 4.2(a) and (b) following results were obtained:

Total seepage Losses before Lining (Cusecs)	**39.508**
Total seepage Losses after Lining (Cusecs)	**1.870**
Saving of Discharge	**37.638**
Extra Land will be cultivated (Acres) as the discharge allowance on Rohri Canal is 4.6 cusecs / 1000acres	**8,182**

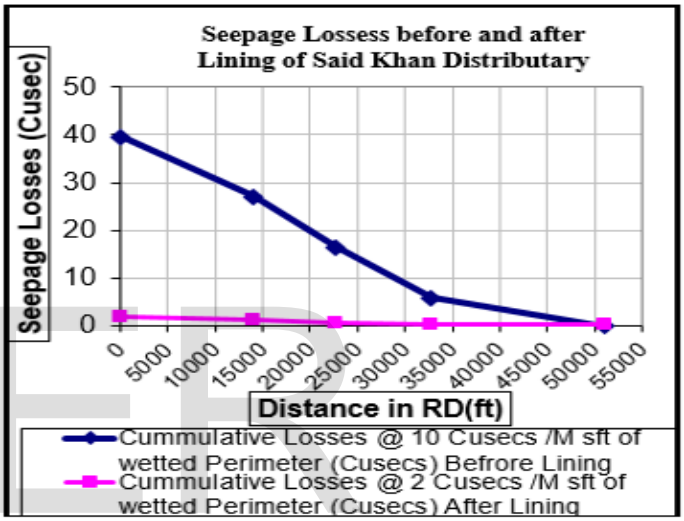

Fig. 4.2: Seepage Losses before and after Lining of Said Khan Distributary

From the Tables 4.1 (a),(b) and 4.2 (a),(b) it is observed the before lining seepage losses of unlined section of Bilawal Zardari Minor and Said Khan Distributary were 33.729 and 39.085 also saving 32.557 and 37.638 cusecs respectively and approximately 7,078 & 8,182 Acers will be extra cultivated on this particular Minor and Distributary.

4.3 CULTURABLE COMMANDED AREA

The results related to the change in CCA of Bilawal Zardari Minor and Said Khan Distributary is given in Table 4.3 & 4.4 respectively.

Table 4.3: Summary of Assessing Effectiveness of Channel before and after Lining of Bilawal Zardari Minor

Water-course No.	Name of Khatedar	Total land owned (Acres)	Area irri-gated be-fore lining (Acers)	Area irri-gated after lining (Acers)	In-crease %
1-AR (Head Reach)	Ali Na-waz	512	388	448	11.72
1-R	Akbar Jamali	40	26	34	20.0
2-L	Atta M.	430	246	395	34.65

(Mid. Reach)					
2-BL	Fareed Zardari	629	329	575	39.12
7-AL (Tail Reach)	Janan Keerio	157	26	139	71.97
7-L	Wadal Shah	324	46	282	72.84
Tail	Ali Khan	130	11	109	75.38

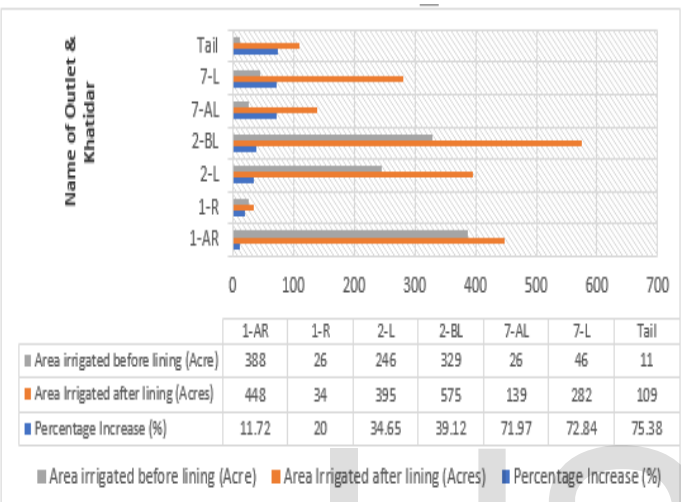

Fig 4.3: Area Irrigated before and After Lining of Bilawal Zardari Minor

Table 4.4: Summary of Assessing Effectiveness of Channel Before and After Lining of Said Khan Distributary

Water-course No.	Name of Khatedar	Total land owned (Acres)	Area irri-gated be-fore lining (Acers)	Area irri-gated after lining (Acers)	In-crease %
1-R (Head Reach)	Dr. Afzal Memon	351	193	249	15.96
1-AL	Allah D. Khowaja	131	79	109	22.90
3-BL (Mid-dle Reach)	Arbab AbJabbar	438	218	386	38.36
2-L	Arbab Imran	1246	379	1021	51.52
1-JL	Ghulam Rasool	74	16	64	64.86
3-L (Tail Reach)	Haji Taj M. Arbab	281	24	218	69.04
3-DR	Haji Gh. Raheem	71	07	59	73.25

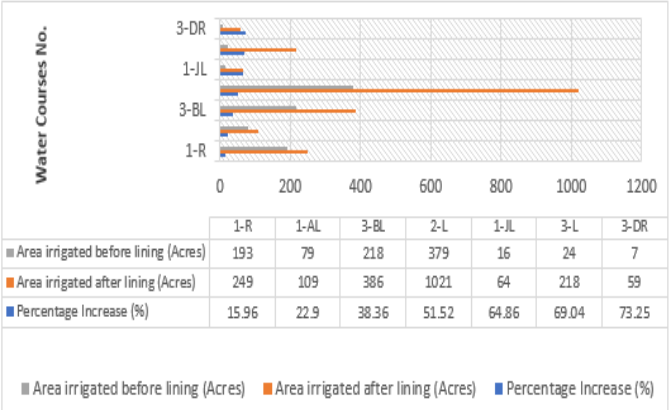

Fig 4.4: Area Irrigated before and After Lining of Said Khan Distributary

From the above tables and graphs, it is observed that the water conveyance efficiency can be improved after lining of the Distributary & Minors to get more land for cultivation and water can be saved for more utilization/cultivation of agriculture land.

4.4 CROPPING INTENSITY

The results related to the change in cropping intensities are given in Table 4.5 & 4.6 as under which is based on farmer's experience.

Table 4.5: Pre and Post Improvement Cropping Intensity of Bilawal Zardari Minor

S#	Name of Outlet	Cropping Intensity		Increase %
		Before Lining	After Lining	
1	1-AR (Head Reach)	68.0%	81.0%	13.0%
2	1-R	62.50%	90.0%	27.50%
3	2-L (Middle Reach)	75.0%	92.0%	17.0%
4	2-BL	73.0%	94.0%	21.0%
5	7-AL (Tail Reach)	67.0%	95.0%	28.0%
6	7-L	76.0%	94.0%	18.0%
7	Tail,	50.0%	88.0%	38.0%
	Overall	**67.35%**	**90.57%**	**23.22%**

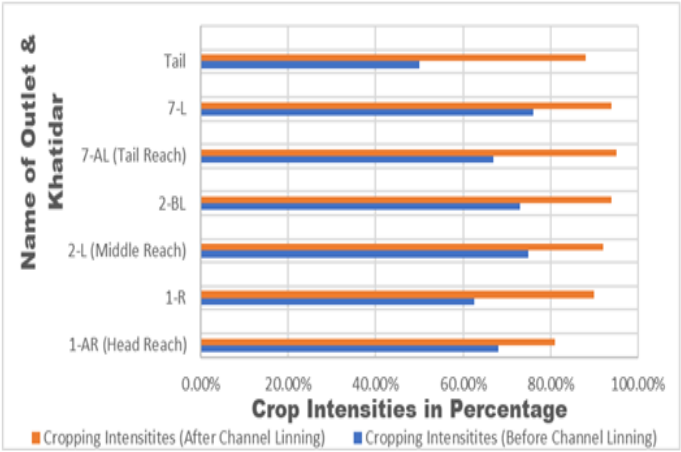

Fig. 4.5: Pre & Post Cropping Intensity of Bilawal Zardari Minor

Table 4.6: Pre and Post Improvement Cropping Intensity of Said Khan Distributary

S#	Name of Outlet	Cropping Intensity		Increase
		Before Lining	After Lining	%
1	1-R (Head Reach)	24.0%	43.0%	19.0%
2	1-AL	34.0%	65.0%	31.0%
3	3-BL(Middle Reach)	15.0%	22.0%	7.0%
4	2-L	12.0%	15.0%	3.0%
5	1-JL	65.0%	88.0%	23.0%
6	3-L (Tail Reach)	64.0%	80.0%	16.0%
7	3-DR	92.0%	112.0%	20.0%
	Overall	**43.71%**	**60.71%**	**17.0%**

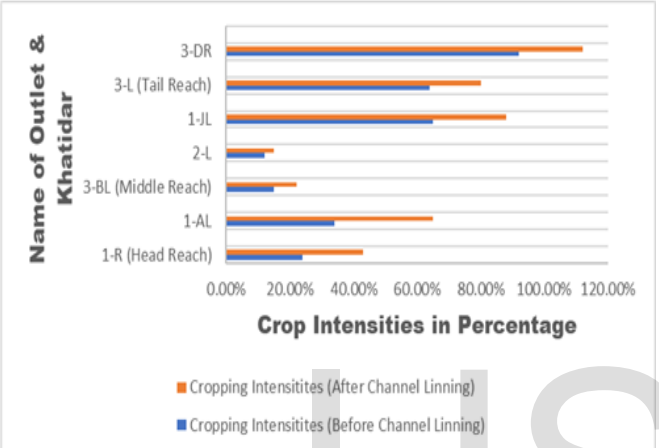

Fig. 4.6: Pre & Post Cropping Intensity of Said Khan Distributary

Social Part: For finding social limits a survey was set up for leading a social meeting from head, center and last part ranchers.

5 Conclusions

From this study following conclusions are drawn:

- Reduction of seepage losses resulted the extra cultivation n the distributary by saving water.
- Total seepage loss of Bilawal Zardari Minor was calculated before lining as 33.729 cusecs (39%) that reduced to 1.17 cusecs (2%) after lining, saved 32.557 cusecs (37%).
- With the saving of 32.557 cusecs that helped in cultivating 7,078 acres of land that was barren before lining of the canal.
- In the same way, before lining seepage losses of Said Khan Distributary were calculated as 39.085 cusecs (51.19%) that reduced to 1.87 cusecs (2.4%) after lining, saved 37.638 cusecs (49.3%).
- The saved 37.638 cusecs of water on Said Khan Distributary helped to cultivate 8,182 acres of barren land.
- By concrete lining problem of water logging & Salinity has been minimized to the tune of reducing seepage toward water-table.
- Percentage increase in the area irrigated after lining of the Bilawal Zardari Minor ranged between 16.27-43.48% & Said Khan Distributary ranged between 18.75-47.06%.
- Percentage increase in the area irrigated after lining of the Percentage increase in overall cropping intensity of Bilawal Zardari Minor &Said Khan Distributary are raised to 23.22%.& 17.0% respectively
- Construction of Lining of distributary is also economicaIIy viable.
- Lining ensured stable section and substantially decreased the cost of desilting of Distributaries every year and sustained the carrying capacity of the distributaries/Minors under study.
- A potential uplift in socio - economic conditions in the study area was witnessed, 33% of landowner households constructed pacca house and installed a tube well while 10% landowners purchased refrigerator and bicycle. In contrast 33% tenant households constructed 3-rooms katcha house and purchase pair of bullocks, motorcycles, TV, carts and milking goats for their livelihood.

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