

Research Paper**IMPACT OF WATER LOSSES AND MAINTENANCE OF CANAL IRRIGATION SYSTEM
ON AGRICULTURE****(Case Study: URMAR MINOR OF WARSAK GRAVITY CANAL PAKISTAN)****ABSTRACT**

A study was conducted in May-August 2005 to assess the conveyance losses, seepage losses, maintenance status and impact of water losses and maintenance on the agricultural yield in case of irrigation channels. In this regard, a case study was conducted on three watercourses, at Urmur Minor of Warsak Gravity Canal irrigation system in Pakistan. The Inflow-outflow method was used to determine conveyance losses and seepage losses were found by ponding method. Local farmers were interviewed to evaluate the maintenance status of the selected water courses. There was found a considerable decrease in the yield of wheat and maize while moving along the channels from head to tail. The irrigation system of Urmur Minor is evaluated as a guiding study and it is generalized to suggest remedial measures to handle widely spread reduction in agricultural production due to these global issues.

Key words: WATERCOURSES, CONVEYANCE, SEEPAGE, OUTLETS, HEAD, TAIL, LEAKAGE, NUKKAS,

INTRODUCTION**GENERAL**

A large amount of irrigation water is conveyed over large distances by watercourses which may be entirely unlined or partly lined. For an uninterrupted supply of water to the land, it is important that the watercourse prism should not only be hydraulically capable of conveying the designed discharge but the banks should also be strong enough to ensure adequate supply to the fields. Since the hydraulic efficiency of the water course section depends largely on the efficient operation and

29 maintenance of the water course; their importance cannot be ignored. It is, therefore, essential that the
30 watercourse should be operated and maintained properly. A study of maintenance impact carried out
31 by Khan [1] revealed that farmers having more water available for their crops pay less attention
32 towards the maintenance of watercourses and socio-economic factors like job, shop-keeping and other
33 such engagements also influence this maintenance process.

34 It has been revealed by a number of investigations that most of the watercourses out of the total 5400
35 watercourses in Khyber Pakhtunkhwa province of Pakistan are improperly designed, carelessly
36 operated and poorly maintained [2]. This eventually causes considerable water wastage and
37 contributes largely to the water-logging and salinity. Hagan [3] found that one-fourth to one-third of
38 all the water diverted for irrigation purposes was lost during conveyance to the field. Rehmat [4]
39 reported conveyance losses of 15 watercourses in three districts of Khyber Pakhtunkhwa ranging from
40 25 to 45 percent. Similarly, Kamper [5] measured 0.24 cusecs water losses using cut throat flume and
41 0.33 cusecs by ponding method in a series of studies. Ejaz [6] during his research on five high water
42 tertiary units and Alam [7] in his research on five low water tertiary units in Kabul River command
43 area found cumulative conveyance losses in terms of seepage and leakage losses. Khan [1] measured
44 conveyance losses of 6 watercourses at Pabbi Minor of River Kabul Canal and Sheikh Yousaf Minor
45 of Lower Swat Canal ranging from 27.3 to 42.5 percent.

46 Corey and Clyma [8] attributed the physical causes for watercourse losses as inadequate hydraulic
47 capacity, leaky nukkas, thin channel walls, inadequate free board, obstructions such as debris, weeds
48 and sediments, poor alignment and excessive ditch system required to serve many small fields.

49 **PROBLEM STATEMENT**

50 This study is focused on the conveyance and real operational losses in the irrigation/farmer channels
51 at the selected outlets. Measurement of conveyance losses in this study gives the loss rate of water per
52 unit length of channel. The steady state water losses due to seepage through the channel sections and
53 direct evaporation from the channel and operational or transient losses due to change in the operation
54 of system such as advance and recession times of the channel and opening and closing of outlets have
55 caused considerable reduction in the agricultural production on a large scale. Besides, poor

56 maintenance and absence of due attention by farmers further aggravate this deficiency in agricultural
57 growth.

58 Keeping in view the problems identified, the irrigation system of Urmar Minor is evaluated as a
59 guiding study and the study is generalized to suggest remedial measures to handle widely spread
60 reduction of agricultural production due to these global issues.

61 **STUDY OBJECTIVES**

62 Keeping in view the problems of water losses in irrigation channels, the following objectives are
63 likely to be achieved from this work:

- 64 1. To report and assess the conveyance losses and conveyance efficiency of the selected
65 watercourses at Urmar Minor
- 66 2. To determine seepage and leakage losses
- 67 3. To find the effect of conveyance losses on crop production at the selected outlets
- 68 4. To suggest measures for minimizing the water losses involved
- 69 5. To check the maintenance status of watercourses under study
- 70 6. To investigate the socio-economic factors affecting watercourse maintenance
- 71 7. To see the overall impact of the identified problems on agricultural growth

72 **STUDY AREA**

73 **WARSAK GRAVITY CANAL**

74 The canal starts at the exit of the 5.6 kilometer tunnel through the Mulkagori Hills on the right bank of
75 the River Kabul and upstream of Warsak Dam. The total length of this canal is 72.8 kilometers (45.2
76 miles) and its full supply discharge is 8.807 cumecs (311 cusecs). The culturable command area of
77 this canal is 23887 ha (59,000 acres). It is located in the Peshawar Valley, the capital of Khyber
78 Pakhtunkhwa. The fig 1 shows the location of Peshawar in Pakistan and gives an idea about the Kabul
79 River movement from Pakistan entering the Afghanistan. Fig 2 shows the branches of River Kabul
80 identifying Warsak Canal in the Peshawar region.

81 Warsak Canal consists of seven minors with a total length of 1984 kilometers (12.4 miles). These
82 minors include Urmar minor, Pabbi minor, Warsak minor, Shahibala minor, Palosi minor, Tehkal
83 minor and Surizai minor.

84 URMAR MINOR

85 The Urmar Minor takes off from the right side of Warsak Gravity Canal at RD 127100 m. It is located
86 in the middle towards tail of the canal. The minor consists of 15 outlets; 6 on the right and 9 on the
87 left. The total length, design discharge and culturable command area of the minor are respectively
88 21200 ft, 12.5 cusecs and 1312 hectares.

89 **Table 1:** The detailed description of outlets at Urmar Minor

S #	Watercourse number	Design Discharge	CCA (ha)	Total length
1	2640/L	1.34	147	4850
2	20000/L	0.57	63	1352
3	21200/L	0.5	55	2080
4	8425/L	0.8	87	1725
5	10200/R	0.402	43	4710
6	1700/L	1.06	116	2587
7	13260/L	0.34	37	812
8	14200/L	0.58	64	1258
9	15750/L	0.35	38	850
10	17880/L	0.332	36	789
11	18290/R	1.41	155	2857
12	21200/T.R	0.95	104	3130
13	8650/R	1.09	119	2275
14	14100/R	1.276	139	2850
15	3520/R	0.99	109	4374

90

91 Out of the above 15 outlets, three watercourses i.e. 10200/R, 21200/L and 21200/T.R were selected
92 for undertaking this study. The watercourse no. 10200/R was completely unlined. The head of
93 watercourse no. 21200/T.R was lined up to 50 meters and the rest remained unlined.

94

95 METHODOLOGY

96 Conveyance Loss Determination

97 The inflow-outflow technique was used to determine water losses by conveyance using the following
98 equations:

$$99 Q_{\text{loss}} = Q_{\text{in}} - Q_{\text{out}}$$

$$100 \text{ Water losses percentage (\%)} = (Q_i - Q_o) / Q_i \times 100$$

$$101 \text{ Losses (\% per 100m)} = \left[\frac{Q_i - Q_o}{Q_i} \times 100 \right] \times \frac{100}{L} = (\% \text{ losses/total length}) \times 100$$

Where: Q_{in} and Q_{out} are the measured discharges at the head and tail respectively and L is the watercourse length under consideration.

In order to measure discharges at head and tail, a cut throat flume (12" x 4") was placed in a straight section of channel in the center, parallel to the direction of flow. Bottom of channel was leveled under the flume and the bottom of flume was placed lower than that of channel. After placement, flume was leveled in both longitudinal and transverse directions. The bottom and sides of flume were sealed to avoid leakage and the inside bottom of flume was cleaned from any sediment or trash to get precise gauge reading. The upstream reading was taken as h_u and the downstream reading was taken as h_d . These values were then converted to flow values by using the appropriate tables from discharge measurement manual by OFWM [9].

Seepage Losses Determination

Seepage rate was determined by ponding method using the equation,

$$S \text{ (m}^3\text{/m}^2\text{/day)} = \frac{24W(d_1 - d_2)}{PLT}$$

Where

S = seepage rate, $\text{m}^3\text{/m}^2\text{/day}$

W = Average width of water surface, m

d_1 = Depth of water at the start, m

d_2 = Depth of water after time T , m

L = Length of ditch, m

P = average wetted perimeter, m

T = time interval between two depths, hour

Since loss rates were highly variable, several measurements with different time intervals (10 to 60mins) were made. Time intervals were short at the beginning due to high seepage rate but were longer as the seepage rate went on decreasing. The measurements were stopped when the seepage reached steady state.

Seepage losses (l/sec) were calculated using the formula,

$$\text{Seepage Loss (l/sec)} = 0.01157 \text{ SPL}$$

129 Where

130 S = seepage rate, $m^3/m^2/day$

131 P = wetted perimeter, m

132 L = total watercourse length, m

133 Leakage losses were calculated by subtracting the steady state seepage losses from the total
134 conveyance losses. A greater portion of the selected watercourses was parabolic in shape and it took 8
135 to 10 minutes to fill the ponding ditch up to the normal depth.

136

137 **RESULTS AND DISCUSSIONS**

138 **WATER LOSSES**

139 It is evident from the results presented in Tables 2 and 3 that the lowest conveyance losses were
140 recorded in water course no. 21200/T.R. This was due to the fact that the section under consideration
141 was totally in shady area and evaporation losses were, therefore, negligible. Moreover, siltation in the
142 watercourse also maintained a low seepage rate. Secondly, it might be due to the reason that it was
143 straight and below the natural surface line and as such the banks and beds were sealed with little
144 leakage and seepage.

145 The maximum losses in watercourse no.10200/R were mainly due to numerous turn-outs increasing
146 leakages at junctions, higher elevation in absence of suitable gradient causing an increase in vertical
147 and horizontal seepage and sharp curves contributing to frictional losses. The overtopping due to high
148 discharge also contributed.

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150

151 **Table 2:** Water losses, conveyance efficiency and channel usage of the selected water courses

Watercourse no.	10200/R	21200/L	21200/T.R
Measured discharge at head (l/sec)	42.65	31.63	45.93
Measured discharge at tail (l/sec)	31.05	27.18	42.30
Water losses percentage	27	14	8
Water losses percentage per 100 meters	0.57	0.67	0.23
Conveyance efficiency percentage	73	86	92

152

153 **Table 3:** Seepage losses in the selected water courses

Watercourse no.	10200/R	21200/L	21200/T.R
Average Depth, cm	14.10	24.12	28.86
Wetted perimeter, cm	53	207	189
Infiltration rate, cm/hr	2.15	3.43	2.83
Width, cm	72.57	54.95	73
Seepage, m ³ /m ² /day	0.384	0.22	0.28

154

155 The main reason of the conveyance losses was poor maintenance and silt deposition in the head of
 156 outlets as farmers lacked cooperation and had little technical know-how; as such the watercourse were
 157 not de-silted on a regular basis. Moreover, hindrance in the flow due to vegetation and trees on the
 158 banks and high water requirement through evapotranspiration greatly decreased the conveyance
 159 efficiency of watercourses.

160 Such results were reported by Ejaz [6] who found average losses of 24%, while Whiting and Javed
 161 [10] reported 22 percent losses in Balu Village Peshawar after sealing the nukkas with mud. Khan [1]
 162 estimated 21.8% losses in Pabbi Minor of Kabul River Canal due to poor maintenance of
 163 watercourses and 14.5% losses in Sheikh Yousaf Minor due to leaky nukkas. Langely and Roob [11]
 164 measured average water losses of 40 percent in Colorado whereas Eire and Leonard [12] mentioned
 165 42 percent water losses in irrigation system from mogha to the farm.

166 **WATERCOURSE MAINTENANCE AND OPERATION**

167 It was revealed from the interviews of farmers conducted through a questionnaire that the frequency
 168 of watercourse clearance was variant based on the extent of silt deposition but the frequency was
 169 higher at the tail than that at the head for the selected watercourses. At watercourse no. 10200/R, 50%
 170 respondents reported watercourse cleaning twice a year, 10% once a year, 10% thrice a year and 30%
 171 four times a year. Tail was cleaned twice a year as area was sandy and sand was deposited in the tail
 172 section. At watercourse no. 21200/L, 50% of the respondents reported watercourse cleaning once a
 173 year and 40% thrice a year. At watercourse no.21200/T.R, the frequency of watercourse clearance
 174 was once a year reported by 40% farmers, twice a year by 50% farmers and thrice a year by 10%. It
 175 was observed that the watercourses were not cleaned for the last two years.

It was reported that in the past there was some kind of informal schedule for water distribution and watercourse periodical cleaning. That was devised and monitored by the senior citizens of that area who besides resolving other disputes, decided about the time and mode of watercourse clearance. Defaulters were subjected to huge fines but with the passage of time, change in the family structure, introduction of new technologies and economic independence due to the jobs gave away to individual dominancy. These days only few farmers belonging to the tail section of watercourses are involved in the cleaning but cannot fine the free riders and cannot monitor those who do not cooperate in maintenance. In Surizai village of Peshawar district, an integrated water management organization was established by the social organizers with the main function to enforce water related policy like water distribution, water course maintenance and collection of water charges. This type of organization is required to settle such disputes. According to the questionnaire, all farmers reported disputes related to maintenance. Tail section farmers considered it injustice that the head and middle section farmers did not participate in maintenance. There was scarcity of cooperation among the farmers for the watercourses maintenance.

AGRICULTURAL DETERIORATION

Watercourse number	% reduction in yield at tail
10200/R	56%
21200/L	47%
21200/T.R	30%

The water losses and inadequate watercourse maintenance and operation have led to the deterioration of agriculture. The crops production has reduced by a considerable amount as shown above.

CONCLUSIONS

From the aforementioned results, it can be inferred that major causes of the water losses were leakage, heavy vegetation on the banks, sharp curves, huge silt deposition, poor design, irresponsible attitude and negligence of farmers, sediment debris in the water channels, and poor maintenance of watercourses and lack of cooperation between farmers regarding periodic clearance. As such, only 40 percent of the farmers get their livelihood from the agriculture in the selected watercourses command area. There was a considerable decrease of 56 percent in the yield of maize and wheat at the tail of watercourses due to these losses. If the average water losses of 32.4 percent are saved through

improving these courses, about 65 cusecs more water could be made available which will be sufficient for irrigating an additional area of nearly 13,000 acres.

RECOMMENDATIONS

In order to minimize water losses, government should take an initiative to form an association comprising of agricultural experts and farmers for creating awareness regarding periodical maintenance and clearance of watercourses, settling the water distribution disputes among the farmers and eventually increasing water conveyance efficiency. Growth of excessive vegetation on the banks should be strictly avoided and measures should be taken to seal the holes made by insects, reptiles and rodents. Periodical removal of silts and sediments should be made on a regular basis. Banks should be well compacted and moghas should not be submerged. As water losses are comparatively more in earthen watercourses, efforts should be made to line these. In case of financial constraints, at least head portion of the watercourses should be lined to increase discharge at the tail. The effect of soil texture on conveyance losses is recommended for the future study.

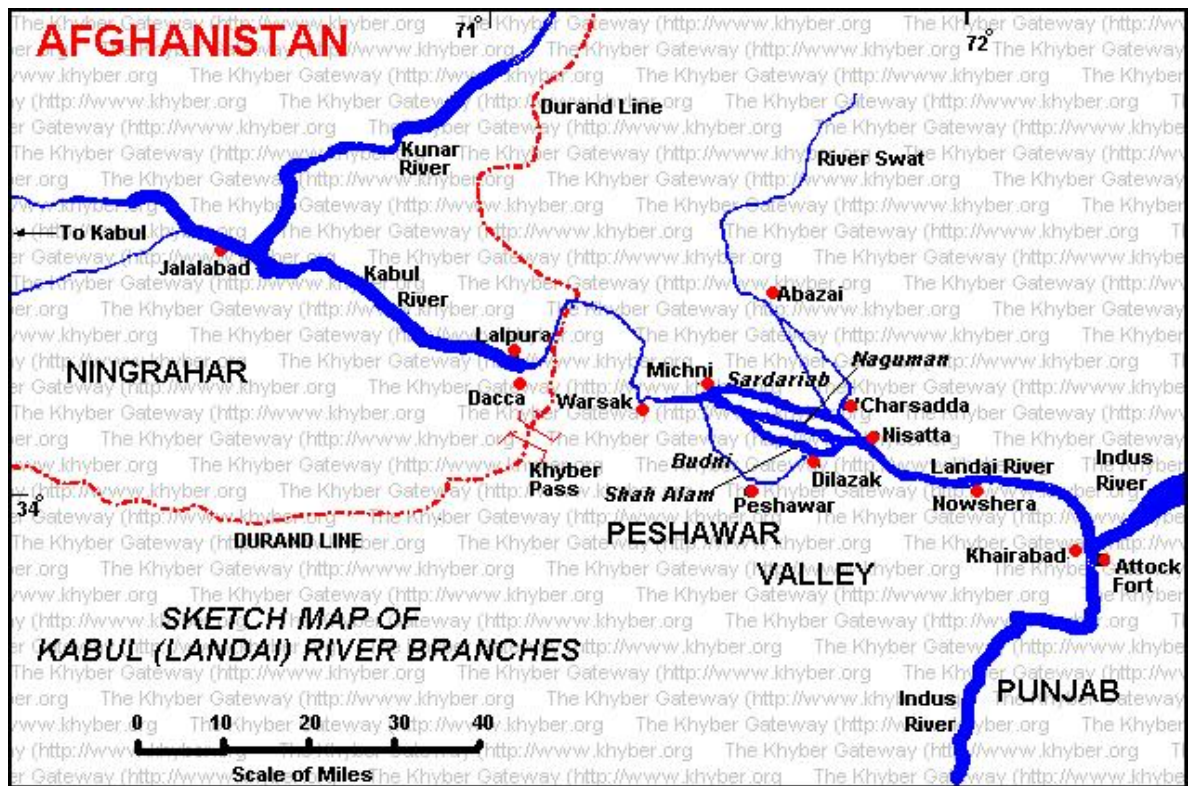
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249 **Figure 2** Kabul River branches identifying Warsak Gravity Canal (source: www.khyber.org)



250
251 **Figure 3** Typical section of cut throat flume

