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An Over View of Irrigation and Drainage Projects in Pakistan

By

Nazir Ahmed
Groundwater Consultant

Sarfaraz Ahmed
Tubewell Consultant.

AN OVERVIEW OF IRRIGATION & DRAINAGE PROJECTS OF PAKISTAN

By

Nazir Ahmad*
And
Sarfraz Ahmad**

SYNOPSIS

i) Out of the usually accepted figure of 142 maf as average annual surface water resource of Pakistan nearly 40 maf was lost to the sea in the years 1977 to 1982. It is suggested to pump a part of this flow when available and divert it for water supply of Karachi. Possibility of groundwater which exists in the river channel below Kotri is also suggested to be withdrawn for use in Karachi.

ii) In the flood plains of the rivers, potential of about 15.00 maf is available which can be exploited and used for agricultural purposes.

iii) During 1977-78, 96 maf was diverted into the canal systems, 46.00 maf out of this seeped underground and about 16.7 maf on the area which includes saline groundwater underneath. Examination of the groundwater quality along depth indicates that nearly 60 percent of this fresh water recharge amounting to 10 maf can be withdrawn by suitable type of tubewells. The remaining about 6.7 maf can be pumped by shallow tubewells or open wells for drainage of the area. The pumped water will have such quality as can be used after mixing with canal or river water. The water withdrawn will collect the present seepage of about one cusec per square mile from the agricultural operations. This amount will increase with future higher diversion and extension of agricultural intensity. The thin depth of fresh water collected in the area will also be pumped out and utilized. These actions will improve the groundwater quality of the shallow aquifer.

iv) These suggestions need careful comparison with respect to the present actions of pumping highly saline groundwater and its disposal into rivers, sea or evaporation tanks.

v) Presently large sums are being spent on construction, operation, maintenance and replacement of tubewells, pumping highly saline useless water which can infiltrate on surface soil. Our suggestions may carefully be reviewed in the light of our present actions which hydraulically and financially are questionable.

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* Groundwater Consultant, 61-B/2, Gulberg-3, Lahore-11

** Tubewell Consultant, 4-C/3, Gulberg-3, Lahore-11

vi) This paper also contains a suggestion to experiment on reduction of losses by evaporation particularly from Lakes and Ponds.

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1. Pakistan Surface Water Resources, Their Utilization and Escape to Sea.

According to Revised Action Programme of WAPDA the total average yearly flow of the Indus and its tributaries is 144.87 maf of which Indus alone contributes 63.9 percent of the total. The monthly flow of the main rivers is given in Table-1 as under and total flow is usually taken equal to 142 maf.

TABLE-1
RIM STATION INFLOW, MILLION ACRE FEET (MAF))

AVERAGE MONTHLY FLOWS

River	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total
Indus	4.0	7.99	15.46	21.96	20.25	9.58	3.51	2.15	1.86	1.77	1.65	2.36	92.54
Jhelum	2.55	3.56	3.66	3.54	2.72	1.50	0.85	0.56	0.49	0.55	0.75	1.54	22.27
Chenab	10.11	2.27	3.65	5.63	5.64	3.04	1.06	0.53	0.43	0.56	0.70	1.11	26.07
Tributary inflow below rim stations	0.14	0.18	0.13	0.44	0.70	0.17	0.12	0.08	0.05	0.02	0.04	0.06	2.13
K. Swat Canals withdrawals	0.17	0.19	0.19	0.19	0.17	0.18	0.18	0.13	0.12	0.10	0.10	0.14	1.86
													G.Total: 144.87

Source RAP Vol.I Table V-I, Page v-3.

The water resources of the Indus and its tributaries were started to be utilize in 1849 when the first Bari Doab Canal was taken out of Ravi at Mohdopur. Slowly the water resources of all rivers continued to be utilized and diversion correspondingly increased. The outflow into the sea continued to decrease. In Table-2 below data of total inflow and diversion both in Kharif and Rabi and the outflow into the sea is given.

TABLE-2

WESTERN RIVER INFLOWS, CANAL DIVERSIONS AND OUTFLOW TO SEA

(Million Acre Feet)

	Kharif		Rabi		Annual		Outflow to Sea
Year [a/]	Inflow	Diversion	Inflow	Diversion	Inflow	Diversion	
1960-61	124.97	54.51	20.74	25.80	145.71	80.31	83.47
61-62	119.58	55.65	20.93	27.17	140.51	82.82	82.94
62-63	89.96	58.07	19.85	27.70	109.81	85.77	42.39
63-64	113.40	62.13	21.66	27.16	135.06	89.29	59.60
64-65	116.11	60.31	22.32	29.57	138 43	89.88	69.98
65-66	117.81	65.18	21.09	25.96	138.90	91.14	56.25
66-67	116.64	65.34	23.83	29.19	140.47	94.53	66.61
1961-67(Avg)	114.07	60.17	21.49	27.51	135.56	87.68	65.89
67-68	120.43	61.94	25.76	32.96	140.19	94.90	69.49
68-69	115.63	66.62	23.21	31.62	138.84	98.24	50.49
69-70	114.49	67.57	19.76	30.72	134.25	98.28	42.97
70-71	90.20	60.75	15.89	26.51	106.09	87.26	25.74
71-72	88.27	60.61	15.74	26.34	104 01	86.95	23.19
72-73	101.62	68.58	24.45	32.23	126.07	100.81	21.42
73-74	145.20	63.42	19.77	32.68	164.07	96.10	67.23
74-75	80.63	62.91	19.66	23.64	100.29	86.55	8.19
1968-75(Avg)	107.06	64.05	20.53	29.59	126.73	93.64	42.34
75-76	116.29	62.96	23.22	36.04	139.51	99.00	39.21
76-77	116.85	58.47	18.43	38.86	135.28	97.33	39.03
77-78	104.36	64.53	29.72	38.15	134.08	102.68	30.37
1976-78(Avg)	112.5	61.99	23.79	37.68	136.29	99.67	36.20

Source: Water Resource Management Cell Wapda.

a/ April to March.

Although the outflow into sea for certain years like 1974-75, 1972-73, 1971-72 and 1970-71 has been very low but the average yearly run off into the sea is about 44.0 maf.

Kotri is the last barrage on the Indus. Any flow escaping downstream of Kotri goes waste to sea. In Table-3 order of escapes below Kotri during the years 1976-77 1976-77 to 1983-84 is given.

TABLE – 3

POST TARBELA ESCAPAGE OF INDUS BELOW KOTRI BARRAGE IN CUSECS

Period		1976-77	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	Mean	Minin
Apr.	1-10th	4276	6764	13564	46396	0	9841	772	0	10202	
	11-20th	5086	7444	390	44815	0	32961	5886	1946	12316	
	21-30th	5939	12105	0	49719	0	14080	13332	8363	12942	
May	1-10th	14880	11178	4563	43407	0	59627	8535	47343	23692	
	11-20th	28667	213	6282	64765	0	117738	28633	38430	35591	
	21-31st	37001	0	52178	56473	0	133049	22224	48175	43638	
Jun	1-10th	34279	0	82694	12657	0	131053	193	49457	38792	
	11-20th	27513	15985	102772	0	5070	73833	1415	74590	37647	
	21-30th	90688	5065	97869	49773	56661	2771	5345	41459	43704	2
Jul	1-10th	14582	45463	118223	125618	20577	52763	4040	62959	55528	4
	11-20th	59751	106344	275940	86357	98532	93013	11905	118284	106266	11
	21-31st	224602	212289	410206	157168	67171	111145	7328	60567	157310	7
Aug	1-10th	311217	256132	557402	223478	105054	200789	5381	102418	220236	5
	11-20th	464143	292789	603900	279090	166398	275079	65749	185169	291790	65
	21-31st	705628	176563	667522	153339	223500	239203	189282	236993	335264	153
Sep	1-10th	413025	143769	462907	56682	121518	75147	85259	314282	209074	56
	11-20th	460247	85908	131643	0	21996	20414	2437	429865	144064	
	21-30th	231823	30494	83354	8567	39519	10772	120	170077	71841	
Oct	1-10th	60519	33043	31912	12183	16241	3678	2843	20958	22672	2
	11-20th	30103	7939	43696	2653	9446	2920	2899	9994	12581	2
	21-31st	18553	12002	25394	165	2076	0	2902	2612	7963	
Nov	1-10th	12575	6083	17872	0	979	0	2770	2156	5304	
	11-20th	11624	0	8323	0	0	0	250	1048	2656	
	21-30th	9568	0	949	0	0	0	0	797	1414	
Dec	1-10th	11284	0	0	0	0	0	0	233	1440	
	11-20th	13447	0	0	0	0	0	0	791	1780	
	21-31st	10408	1439	2862	1331	2880	2377	1210	11678	4273	1
Jan	1-10th	11177	673	4104	2838	4736	3384	1652	9123	4711	
	11-20th	12191	0	51	949	10403	0	0	8725	4040	
	21-31st	11890	0	0	1863	8222	50	0	20975	5375	
Feb	1-10th	19164	0	22	0	13798	339	0	15102	6053	
	11-20th	11366	0	0	0	11449	0	0	381	2900	
	21-28/9th	1005	0	869	0	5190	0	0	0	893	
Mar	1-10th	0	0	27818	0	874	0	0	0	3587	
	11-20th	0	0	77790	0	0	0	0	0	9724	
	21-31st	3026	5208	41092	0	0	0	0	0	6166	

Source: Data from Kotri Barrage.

Minimum flow from middle of June to the end of August has varied between 300 to 6000 cusecs although the mean value for these months has varied between 4000 to 30,000 cusecs. In several years the high order flow has risen from 50,000 to 70,000 cusecs per day. The yearly mean flow going waste to sea has varied every year. During 1978-79, about 80.67 maf escaped to sea while in 1982-83 the escape was 9.81 maf. The mean of these eight years was 39.87 maf.

2. Water Losses from Irrigation System

(a) Seepage losses from water diverted into canals.

Pakistan is fortunate to possess an extensive and very deep unconsolidated formation mostly having sandy deposit to retain surface infiltration. Indus plains constituting about 40 m.ac. posses means of spreading water at surface through innumerable canal system. From time immemorial this formation has been receiving infiltration from the surface streams and from rainfall. With the extension of irrigation system and increased spreading of water at surface for cultivation, infiltration has continued to increase.

An estimate of recharge occuring in the four Provinces is given in Table-4 as under.

TABLE-4
GROUNDWATER RECHARGE IN CANAL COMMANDS (1977-78)

Name of Command	Gross Area (MA)	Area of Usable Ground Water (MA)	Area of Saline Ground Water (MA)	Canal Delivery (MAF)	Total Recharge (MAF)	Recharge on usable ground Water (maf)	Recharge on Saline Ground Water (maf)
Punjab	24.319	20.190	4.129	53.147	27.429	23.115	4.314
NWFP	0.988	0.988	-	2.692	1.400	1.400	-
Sind & Saluchis-tan	15.427	3.694	11.733	40.052	16.748	4.386	12.362
Pakistan	40.734	24.872	15.862	95.891	45.577	28.901	16.676

Source– Groundwater Development and Potential in Canal Commanded Areas of the Indus Plains,Planning Division, WAPDA, July 1981.

With canal delivery of 96 maf, a recharge of 45.6 maf occured on the irrigated area of the Indus plains. The recharge in the Punjab and N.W.F.P. was nearly 50% of the diversion, whereas in Sind and Baluchistan it was 42%. The recharge on usable groundwater area is 44% for the Punjab and 52% for NWFP but for Sind it is only 11% and the remaining about 31% of the total occured on saline groundwater area.

2.1 Definitation of Saline Groundwater

An area with saline groundwater is defined such that at a depth of 350 feet the water contains soluble salts upto 3000 ppm. The shallow water may have salinity less than this order. Areas have been determined in the Indus plain which possess salinity of 1000, 1000 to 1500, 1500 to 3000 and above 3000 within depths of 350 and 125 feet. This information is given in Table-5 below.

TABLE-5

WATER QUALITY DISTRIBUTION IN DEPTH RANGES OF 350 FT. AND 0-125 FT

Region	Gross Area	Percentage of Area in TDS (ppm) Range			
	(million acres)	Less than 1000	1000-1500	1500-3000	more than 3000
PUNJAB					
Chaj Doab	2.474	62.7(72.2)	9.7(10.1)	9.6(4.9)	18.7(12.3)
Rechna Doab	5.729	62.5(64.5)	14.4(12.0)	15.4(16.9)	7.7(6.6)
Bari Doab	7.004	62.6(77.4)	17.0(15.2)	12.7(4.8)	7.7(2.6)
Thal Doab	3.977	59.8(64.9)	13.3(12.6)	15.2(12.5)	12.2(10.0)
Sutlej L Bank	4.178	32.8(43.8)	8.7(8.6)	12.9(8.5)	45.6(39.1)
Sutlej R Bank	0.957	31.4(59.4)	21.8(12.3)	15.1(10.4)	31.7(17.9)
Sub Total	24.319	55.7(65.4)	13.8(12.2)	13.5(9.8)	17.0(12.6)
SIND-BALUCHISTAN					
Gudu R. Bank	1.252	6.6(10.0)	12.9(10.5)	11.9(26.5)	68.6(52.3)
Gudu L. Bank	0.960	22.3(31.6)	6.7(8.6)	19.6(14.9)	51.4(44.9)
Sukkur R. Bank	2.437	6.3(7.5)	4.5(9.1)	15.2(9.1)	74.0(64.3)
Rohri-Khairpur	3.948	25.2(47.4)	8.9(9.5)	13.7(20.7)	52.2(22.4)
Nara	2.514	1.2	(2.7)	(2.6)	100(93.5)
Kotri	3.316	(0.7)	(1,0)	(1.4)	100(96.9)
Sub Total	15.427	9.8(17.2)	5.3(6.6)	8.8(13.8)	76.1(62.4)
Total Basin	39.746	39(48)	10(10)	12(11)	39(31)

Figures in parenthesis indicate TDS concentration in 125 ft. depth range

Source: WAPDA R.A.P. Vol.I report, 1979.

With shallow depth of 125 feet the area with groundwater salinity of 1000 ppm and 1500 ppm increases. This shows that at shallow depths groundwater of low salinity exists. As the fresh water infiltrates at all the irrigated areas irrespective of groundwater quality, one can except a thin layer of fresh water at practically all irrigated lands.

(b) Loss of Water by Evaporation from Free Water Surface.

Evaporation loss occurs from flowing as well as ponded water. Pakistan possesses about 38,936 miles of main canals and branches. There are about 89,100 water courses which deliver water to about 26 m.ac. which are annually cropped. Since 1876 engineers and scientistis have tried to estimate the conveyance loss of the flowing water. As a result of studies by different workers it is established that about 20 percent is the loss through the main canals and branches, about 6 percent through distributaries and 20 percent through water courses. This loss is due to percolation and evaporation. For the canals, branches and distributaries evaporation is taken as 20% of the total loss and the rest 80% is the percolation. In case of water courses the evaporation is 50% of the total loss. Harza in 1963 tried to work out the seepage and evaporation loss from rivers and canals both for northern and southern regions. The results of their studies are given in Table-6 below.

TABLE-6

AN ESTIMATE OF SEEPAGE AND EVAPORATION LOSS FROM RIVERS AND CANALS

Northern Area – The Punjab (Unit area in maf)

Site	Inflow at head	Outflow at tail	Seepage	Evaporation	Total Loss
Rivers	140	73.9	1.9	8.2	10.00
Canals	61	40.0	16.8	3.8	20.6
Water courses supplies from Canals=40.4 G.W = 22.4)	62.8	56.5	3.3	3.2	6.5
Crop use (fields)	56.5	–	8.5	5.0	14.1
Rainfall Percolation	–	–	32.6	–	–
Total Losses	–	–	32.6	20.8	53.4
		Southern Area (Sind)			
Rivers	73.9	37.9	1.2	3.7	4.9
Canals	31.1	21.8	7.4	1.9	9.3
Water courses supplies from Canals 21.8) G.W. 4.5)	26.3	37.9	1.3	1.3	2.6
Crops use (fields)	23.7	–	3.5	2.4	5.9
Rainfall percolation	–	–	0.2	–	–
Total	–	–	13.6	9.3	22.9

In term of percentage and evaporation losses from various sources for Northern and Southern areas are given in Table-7 as under.

TABLE-7

PERCENTAGE LOSS BOTH AS SEEPAGE AND EVAPORATION

Northern Area

Sites	Seepage	Evaporation
Rivers	19.0	81.0
Canals	81.6	18.4
Water Courses	49.9	50.1
Fields	60.0	40.0

Southern Area

Rivers	12.4	87.6
Canals	80.2	19.8
Water Courses	50.0	50.0
Fields	59.0	40.7

WAPDA Master Planning and Review Division examined 7 years data from October, 1967 to September 1974 and came to the same conclusion as those determined by Harza.
by Harza.

The studies indicated that with 92 maf of diversion nearly 30 maf of water is lost as evaporation from rivers and canal system. This loss is out of flowing water. There is practically little possibility to save this loss.

Evaporation also occurs from ponded water. There are 15 storages the evaporation loss from which is estimated equal to 2.13 maf. There are other minor dams which have water available for about eight months. These lose 210.35 cusecs.

Losses from Mancher, Kalari and other lakes are estimated about 2630.3 cusecs. An estimate of loss was carried out from village ponds and from ponds existing upstream of barrages. These studies indicated that a loss of about 6.51 maf occurs from the ponded water. The details of loss from each type of pond is given in Table-8 as under.

Table – 8 An estimate of Water Loss by Evaporation in Pakistan from free water surface.

S.No.	Sites	Evaporation loss per year	
		Cusecs	maf
1.	Dams and storages of significant size	2940	2.13
2.	Small Dams	210	0.15
3.	Lakes	2630	1.19
4.	Village ponds	730	0.54
5.	Ponds above barrages	2441	1.78
	Total :	8951	6.51

(c) Loss of water by evaporation from Soil having high Water Table.

There are large areas in the Indus plains which possess groundwater within 5 feet from surface. The groundwater continues to move upward and leave soluble salts near the surface. Those areas which possess comparatively high order of salts become completely barren with no vegetation on surface. WAPDA has given an estimate of areas with water table within 5 feet in their Master Plan. This information is reproduced in Table-9 below.

TABLE-9

LOSS OF WATER BY EVAPORATION FROM BARE SOIL HAVING WATER TABLE UPTO 5 FEET DEPTH

Province	CCA with Water Table upto 5 ft. (acres)	Annual FWS Evaporation Inch/Unit area	Av. Annual Evap. in ft. per Unit area	Evap. loss in ac. ft. from the area	Evap.loss in cusecs from the area
NWFP	18,410	60	1.75	32,217.5	44.33
Sind and Baluchistan	2,82,960	85	2.48	61,55,671.5	8432.43
Punjab	18,58,460	70	2.04	37,94,355.7	5197.75
Total :	43,59,830	–	–	99,82,244.7	13674.31

In NWFP only 18,410 acres possess groundwater within five feet. Such areas for Sind/Baluchistan are 2.483 m. acres and in the Punjab 1.858 m. acres. Assuming the average depth of groundwater at 3.5 feet the evaporation loss was determined as given in Table-9. It was found equal to 13,674 cusecs corresponding to about 10 maf. It may be noted that groundwater in all these areas is not saline. There are many fresh high groundwater areas particularly in the Punjab where in the 9.476 m. acres lying outside SCARPS, about 0.825 million acres have water within 5 feet. All this is fresh water which is being lost from soil by evaporation.

Pakistan thus losses about 40 maf of usable water, 30 maf from flowing canals and rivers, 6.5 maf from ponded water and about 4.4 maf from bare soil with water table within 5 feet.

3. Improving Surface Water Resources of Pakistan

3.1 Use Indus Water below Kotri Barrage for Supplies to Karachi.

The present water supply for Karachi is estimated equal to 290 mgd. which is being supplied mainly from surface water resources of the Indus. The water of this river is stored in Kalri Lake (now called Kinjar Lake). Another Haleji Lake located near Kalri and fed from Kalri was the ori-

ginal source of water supply for Karachi put into operation in 1940. The sources of present water supply are as under :

Source	Water Supply
Dumolttee Open wells working since 1886	1 to 4 mgd.
Haleji/Gharo System	20 mgd.
Greater Karachi Bulk Supply	210 mgd.
Hub Dam System	60 mgd
Total :	291 to 294 mgd.

The present requirement of Karachi is about 374 mgd. which is 80 mgd. short of the availability. It is estimated that by 1990 and 2000 the requirement will rise to 510 and 830 mgd. respectively. This much additional water may not be available at Kotri Barrage to feed the Kinjar Lake. Considerable volume of water is escaped below Kotri during July, August and September. In certain years flow is available even in the months of January, February, March and April. The Indus River is not too far off from the tail end of Kanjar Lake. It is suggested that the future water supply of Karachi may be based on conjunctive use of water escaped below Kotri Barrage and that stored in Kanjar Lake.

The volume of escaped water during monsoon is sometimes 10 to 30 thousand cusecs per day. Seepage pressure through this much water can push the saline sea water. The elevation at Kotri is about 60 feet. One can expect a build up of fresh usable water in the bed of the river perhaps to a depth of 100 feet or more. After monsoon with the shrinkage of the river channel the seeped water regenerate into the river channel and gets lost by evaporation. It is possible that after ascertaining the depth of usable water strainers can be provided along and across the bed of the river at suitable depths and groundwater pumped out can be supplied to Karachi. A few miles length of the Indus starting below Kotri can yield sufficient water for the requirements of Karachi. This can prove an additional source besides the surface run off.

3.2 Utilizing Groundwater Resources of the Flood Plains

Flood plains have always been extensively cultivated particularly after the monsoon flood season. The land formation used to be recharged by fresh water and the moisture left in soil was sufficient to grow Rabi crops. The soil also received spreading of fresh silt which fertilized the soil. Any requirement of water to mature crops was received from winter rains or by withdrawing groundwater through Persian Wheels. With the construction of canals the frequency of flooding has continued to decrease. These active flood plains were also left out of the irrigation canal system due to expected damage to the canals during floods. Still the spreading of less intense floods of short duration, the area was cultivated depending more on groundwater which at places was started to be extracted by tubewell. Presently a big change in the earstwhile conditions has come in. The river Sutlej and Beas have been completely diverted and controlled by India. Ravi river resources have also been diverted although some high intensity floods still pass through Pakistan but very soon with complete control of the river, flood waters will also be completely retained. In case of Jhelum and Indus with the construction of Mangla and Tarbela dams, flood plains are now receiving very little flood spills. This is a particular case with the Jhelum.

Some change have also occured in the flood plains of the Chenab. In Sind embankment are in existence starting from Gudu Barrage down to the Sea. The area enclosed between the bund do receive flow annually from floods but to a much lesser degree. Still these areas are being cropped wherever possible.

The length of the various rivers is about 1,759 miles and presently 5.44 million acres are included in the flood plains. WAPDA in the Revised Action Plan Vol.I has estimated the possible groundwater potential from Riverain area. A potential of usable groundwater for the Indus from Kalabagh (Jinnah Barrage) to Kotri and for the Chenab from Marala to Panjnad was estimated to be 15.626 maf as given in Table-10 as under :

TABLE-10

POTENTIAL FROM RIVERAIN RESERVOIR

Name of River	Reach	Length (Miles)	Average width (Miles)	Potential (M.A.F.)
Indus (Lt. Bank)	Jinnah-Chashma	33	4	0.356
" "	Chashma–Taunsa	140	4	1.532
" "	Taunsa-Mithankot	95	4	1.084
" "	Mithankot-Gudu	72	4	0.837
" "	Gudu-Sukkur	80	4	0.782
" "	Sukkur-Kotri	128	4	1.242
Indus (Rt. Bank)	Chashma-Taunsa	140	4	1.371
" "	Taunsa-Gudu	168	4	1.933
" "	Gudu-Sukkur	80	4	0.839
" "	Sukkur-Sehwan	76	4	0.594
Chenab (Lt. Bank)	Marala-Khanki	32	2	0.174
" "	Khanki-Quadrabad	17	2	0.089
" "	Quadrabad-Trimmu	119	2	0.759
" "	Trimmu Panjnad	162	2	1.157
" "	Panjnad	32	4	0.320
Chenab (Rt. Bank)	Marala-Khanki	32	2	0.186
" "	Khanki-Quadrabad	17	2	0.081
" "	Quadrabad-Trimmu	127	2	0.837
" "	Trimmu-Panjnad	162	2	1.188
" "	Panjnad	32	4	0.265
			Total	15.626

Planning and Investigation Department of WAPDA recently conducted studies for certain areas to determine suitable agricultural lands and potential of groundwater which could be developed in these areas. For Punjab these studies have been confined from Hussainewala to Panjnad for Sutlej, from Mangla to Trimmu on the Jhelum and from Kalabagh to Mithankot on the Indus. Information extracted from WAPDA report is put forth in Table-11 below. For about 1.628 m.ac. of CCA in case of the Punjab a groundwater potential of 4.322 maf exists.

Similar studies have been carried out for Chashma to D.I.Khan along right bank of the Indus and from Gudu to Sukkur. Both culturable lands and groundwater potential exist in these areas as given in Table-11.

TABLE-11

FRESH GROUNDWATER POTENTIAL IN RIVERAIN AREAS*

NO.	Description	Area (m.ac.)		Development Potential (MAF)
		GCA	CCA	
1.	Punjab			
	. River Sutlej (Hussainiwala to Panjnad)	0.466	0.420	0.576
	. River Jhelum (Mangla to Trimmu)	0.242	0.222	0.746
	. River Indus (Kalabagh to Mithankot)	1.075	0.986	3.00
2.	NWFP			
	River Indus Right Bank (Chashma to D.I.Khan)	0.088	0.052	0.115
3.	Sind			
	River Indus (Gudu to Sukkur)	0.450	0.179	0.334
	Total:	2.321	1.859	1.771

Source: Revised Action Plan Vol.1 of Wapda.

* Areas where groundwater investigations have been carried out by Wapda P&I Department.

In Riverain area with very suitable land, very little problem of salinity, some surface water as well as groundwater is available. It is thus possible to plan a conjunctive use of surface and groundwater development to utilize the culturable lands available in these areas. Of course special

type of tubewells shall have to be installed in the active flood plains. Presently much of the potential of these area is being lost as evaporation and evapotranspiration by shrubs and weeds. Besides the estimate of groundwater potential of the Indus and Chenab of 15.0 maf additional potential of these areas is being lost as evaporation and evapotranspiration by shrubs and weeds. is still to be determined. Suitable type of tubewells installed in the flood plains can thus increase our water resources.

3.3 Obtaining Usable Groundwater from the Zone of Saline Groundwater.

In Table-4 the diversion into canal during 1977-78 has equal to 95.9 maf. The percolation equal to 45.6 maf. occured on area irrespective of groundwater quality. The proportion which occured on areas of saline groundwater was 4.31 maf. in the Punjab and 12.36 maf. in Sind.

The area of usable and saline groundwater for each canal command has been worked out and is given in Table-12 below.

TABLE-12

AREAS OF USABLE AND SALINE GROUNDWATER ZONES
BY CANAL COMMANDS

Sr.	Canal Command	C.C.A. (MA)	G.A.(M.AC.).		
			Total	Usable Zone	Saline Zone
	PAKISTAN	34.631	40.734	24.872	15.862
(A)	PUNJAB	20.269	24.319	20.190	4.129
1.	Upper Dipalpur	0.360	0.421	0.421	–
2.	Ravi Syphon/CBDC	0.649	0.794	0.646	0.148
3.	Raya Branch	0.424	0.442	0.442	–
4.	Upper Chenab canal	1.017	1.114	1.114	–
5.	M.R.Link	0 158	0.167	0.167	–
6.	Sadiqia	0.969	1.163	0.108	1.055
7.	Fordwah	0.426	0. 57	0.446	0.111
8.	Pakpattan	1.049	1. 23	1.088	0.035

9.	L. Dipalpur	0.615	0.723	0.723	–
10.	L.B.D.C.	1.670	1.993	1.898	0.095
11.	Jhang	1.168	1.730	1.535	0.195
12.	Gugera	1.566	2.097	1.862	0.235
13.	U.Jhelum	0.544	0.688	0.682	0.006
14.	L Jhelum	1.500	1.786	1.330	0.456
15.	Bahawal	0.605	0.814	0.591	0.223
16.	Mailsi	0.996	1.081	0.845	0.236
17.	Sidhanai	0.869	0.869	0.850	0.019
18.	Haveli	0.179	0.179	0.166	0.013
19.	Rangpur	0.344	0.416	0.389	0.027
20.	Panjnad	1.348	1.490	1.059	0.431
21.	Abbasia	0.154	0.154	0.069	0.085
22.	Thal	1.641	2.752	2.365	0.387
23.	Muzaffargarh	0.809	0.809	0.740	0.069
24.	D.G.Khan	0.909	0.957	0.664	0.303
B.	N.W.F.P.	0.807	0.988	0.988	–
1.	U. Swat	0.279	0.396	0.396	–
2.	L. Swat	0.182	0.210	0.210	–
3.	Warsak	0.119	0.129	0.129	–
4.	Kabul	0123	0.144	0.144	–
5.	Paharpur	0.104	0.109	0.109	–
C.	SIND & BALUCHISTAN	13.555	15.427	3.694	11.733
1.	Pat	0.747	0.808]		0.739
2.	Desert	0.328	0.362]	0.145	0.286
3.	Begari	1.002	1.082	0.562	0.520
4.	Ghotki	0.858	0.960	0.467	0.493
5.	North West	1.215	1.263	0.281	0.982
6.	Rice	0.519	0.543	0.110	0.433
7.	Dadu	0.584	0.631	0.243	0.388
8.	Khairpur West	0.417	0.424	0.371	0.053
9.	Khairpur East	0.373	0.572	0.122	0.450
10.	Rohri	2.561	2.952	1.393	1.559
11.	Nara	2.176	2.514	–	2.514
12.	Kalri	0.592	0.772	–	0.772
13.	L. Channel	0.502	0.582	–	0.582
14.	Fuleli	0.923	1.010	–	1.010
15.	Pinyari	0.758	0.952	–	0.952

Notes:

a) Figures used for CCA and GCA have been taken from Revised Action Programme, WAPDA (1979) except the CCA of Kabul canal which is taken from IACA Report of (1966).

b) Usable zone is the area in which the salt content of the groundwater in 0 to 350 feet depth range is less than 3000 ppm TDS.

c) Saline zone is the area in which the salt content of the groundwater in 0 to 350 feet depth range is more than 3000 ppm TDS.

Such information for Pakistan and for its four provinces, extracted from this Table is given in Table-13.

TABLE-13

AREA OF USABLE AND SALINE GROUNDWATER ZONES BY PROVINCES

S.No.	Zones	CAA (M.Ac.)	G.A. (M.Ac.)		
			Total	Usable Zone	Saline Zone
1.	Pakistan	34.631	40.737	24.872	15.862
2.	Punjab	20.269	24.319	20.190	4.129
3.	NWFP	0.807	0.988	0.988	-
4.	Sind & Baluchistan	13.555	15.427	3.694	11.733

Source: Groundwater Development and Potential etc. WAPDA July 1981

Diversion into each canal command is also available together with its recharge on usable and saline groundwater zones. These data are used to determine the recharge on total area and on usable groundwater zone. This information for Pakistan and its provinces is given in Table-14.

TABLE-14

GROUNDWATER RECHARGE IN ACRE FEET PER ACRE(PERIOD 1977-78)

S.No.	Zone	Total C.C.A. (MA)	Total Recharge (AF/AC)	Usable C.C.A. (MA) (MA)	Usable Recharge (AF/AC)
1.	Pakistan	34.631	1.32	20.972	1.38
2.	Punjab	20.269	1.35	16.842	1.37
3.	NWFP	0.807	1.73	0.807	1.70
4.	Sind & Baluchistan	13.555	1.24	3.323	1.31

Source: Groundwater Development, etc. WAPDA July 1981.

This recharge per unit area is during 1977-78. This condition has existed since the spread of canal system. This fresh water recharge has pushed the saline groundwater and now in a considerable area of saline groundwater zone, usable water exists in varying depths above the saline groundwater.

3.3.1 A few instances of Usable Water Floating on Saline Groundwater.

Data for groundwater quality for several bores drilled in saline groundwater zone is available. Studies for a few bores were carried out and the results are given in several tables.

a) Groundwater Quality in patches of saline groundwater.

In Bari Doab, there are five conspicuous patches of saline groundwater. The water quality of different bores is given in Table-15.

TABLE – 15
VARIATION OF GROUNDWATER QUALITY
WITH DEPTH FOR BARI DOAB

Sr. No.	Well No.	Depth (ft)	TDS (ppm)	Sr, No.	Well No.	Depth (ft)	TDS (ppm)
B–1				B–3			
1.	BR-6	135-155	1630	1.	BR-127	68-86	980
						110-130	590
2.	BR-8	67-87	3600			198-218	700
		270-290	9000			308-328	920
		337-357	7200			418-438	4600
3.	BR-14	48-60	680	2.	BR-61	90-107	6000
		134-135	1470			180-197	7400
		279-290	2170			270-287	10000
		352-360	1990			337-354	6900
4.	BR-139	44- 64	950	B-4			
			950	1.	BR-73	66-86 86	800
		154-174	3380			132-152	970
		283-303	1830			242-262	1015
		393-413	2410				
		1015-1045	600				
5.	BR-16	176-186	1000	2.	BR-70	154-174	655
		220-230	1350			220-240	785
		264-274	1350			330-350	490
		330-340	850	3.	BR-80	66-86	800
		440-450	770			154-174	1000
						242-262	1100
6.	BR-22	154-160	635			330-350	700
		220-232	965				
		396-408	415	B-5			
				1.	BR-74	90-107	580
B-2						157-174	418
						225-242	492
	BR-42	88-108	2180			360-377	412
		154-174	2070				
		220-240	1300	2.	BR-131	198-218	390
		330-350	1350			262-285	400
		396-416	1190			352-372	450
						444-464	770
	BR-45	66-86	620				
		264-284	2020	3.	BR-133	63-83	6100
		330-350	1490			124-144	5010
		396-416	1150			248-268	5900
						332-352	4310
3.	BR-52	66-76	7200			454-474	3100
		220-230	3100			556-576	4300
		286-296	3200				

TABLE–15(Cont.)
BARI DOAB

Sr. No.	Well No.	Depth (ft)	TDS (ppm)	Sr. No.	Well No.	Depth (ft)	TDS (ppm)
B–5							
4.	BR-134	62-82	3300	9.	BR-97	110-130	9800
		144-164	6700			198-218	9100
		226-246	7250			308-388	9800
		307-327	7600			436-456	9700
		516-536	5900				
		664-684	6690	10.	BR-98	38-105	4560
						176-196	5860
5.	BR-85	90-107	850			308-328	6190
		315-332	310			418-478	6520
6.	BR-96	66-86	1600	11.	BR-107	88-108	1500
		198-218	4900			198-218	2800
		308-328	6700			308-328	5500
		396-416	9500			418-438	13050
7.	BR-102	67-84	770	B–5			
		157-174	820	12.	BR-111	110-130	2240
		270-287	3600			198-218	3270
		360-377	4850			308-328	9100
						436-456	8110
8.	BR-106	88-108	1350				
		220-240	2190	13.	BR-120	88-108	720
		308-328	3250			176-196	6200
						286-306	9000
						418-438	8500

TABLE–16
VARIATION OF GROUNDWATER QUALITY
DEPTH FOR BAHAWALPUR AREA

BAHAWALPUR AREA

Sr. No.	Well No.	Depth (ft)	TDS	Sr. No.	Well No.	Depth (ft)	TDS
BW–1				2.	BWP-17	50	1040
1.	BWP-21	170	540			210	530
		270	460			270	590
		310	540				
		370	430	3.	BWP-24	50	760
						250	2540
2.	BWP-13	290	840			290	4350
		350	810			390	4370
						470	5970
3.	BWP-5	250	6130	4.	BWP-9	70	505
						110	11900
4.	BWP-5-A	116	6600			130	1300
		270	6000			170	11540
		410	4800			210	8490
		510	4700				
BW–2				5.	BWP-15	160	465
						270	270
1.	BWP-18	250	1250			370	900
		310	1200				
		370	1050	6.	BWP-8	50	880
		470	1080			90	955
		590	1050			150	1500
						370	8300
BW–3				7.	BWP-7	310	5000
1.	BWP-12	60	1200			470	10700
		170	2500				
		310	1500	8.	BWP-14	70	380
		370	830		830	270	730
		40-52	230			370	900
		150-162	230				
		326-338	510	9.	BWP-6	260	13700
		414-425	490				
				10.	BWP-30	150	9720
	SALINE WATER ZONE					210	9800
						270	10600
1.	BWP-23	250	795			330	9260
		350	1080			450	11940

TABLE–16

BAHAWALPUR AREA

Sr. No.	Well No.	Depth (ft)	TDS (ppm)
11.	BWP-40	84-94	1290
		189-194	10600
		252-260	11500
		320-330	12500
		407-417	12500
12.	BWP-48	152-162	11000
		218-228	10900
		328-338	6800
13.	BWP-37	150	18000
		330	18500
14.	BWP-55	194-206	490
		260-270	530
		348-360	410

Data of other Doabs of the Punjab are very similar and have been left over. As for Sind similar conditions are in existence. Data of a few bores on right side of the Indus is given in Table–17.

TABLE–17

VAIATION OF GROUNDWATER QUALITY WITH DEPTH FOR SIND (OUTSIDE THE Q–5 AREA)

Sr. No.	Well No.	Depth (ft)	TDS (ppm)	Sr. No.	Well No.	Depth (ft)	TDS (ppm)
1.	bh-54	84	4450	11.	GR-11	150	780
		104	3520				
		128	5280	12.	LIPW-129	44-54	960
		168	5075			182-192	1110
						321-331	1850
2.	BH-53	90	11450			440-450	3560
		146	9370			550-560	6930
		176	8255				
				13.	RB-31	74	1500
3.	LIPW-131	44-54	844			118	1820
		165-175	436			162	2545
		310-320	2120			206	3000
		404-414	4890			272	2910
4.	BH-51	76	1395	14.	LIPW-128	44-54	290
		106	2690			189-199	990
		127	1830			307-317	1020
		176	3520			424-434	1350
5.	GR-12	150	460	15.	GR-27	150	1280
6.	RB-37	118	2020	16.	GR-23	150	170
		162	1410				
		206	1580	17.	BH-10	156	1170
		294	2460				
				18.	BH-47	80	2640
7.	BH-52	76	1393			104	2430
		106	2690			144	11460
		127	1830			176	7300
		176	3520				
				19.	GR-28	150	430
8.	BH-49	90	8450				
		120	10175	20	BH-11	240	1730
		150	5400				
9.	RB-36	74	646				
		118	458				
		162	920				
		206	965				
		272	2285				
10.	GR-15	150	1600				

FIG.1 SCHEMATIC SCAVENGER WELL

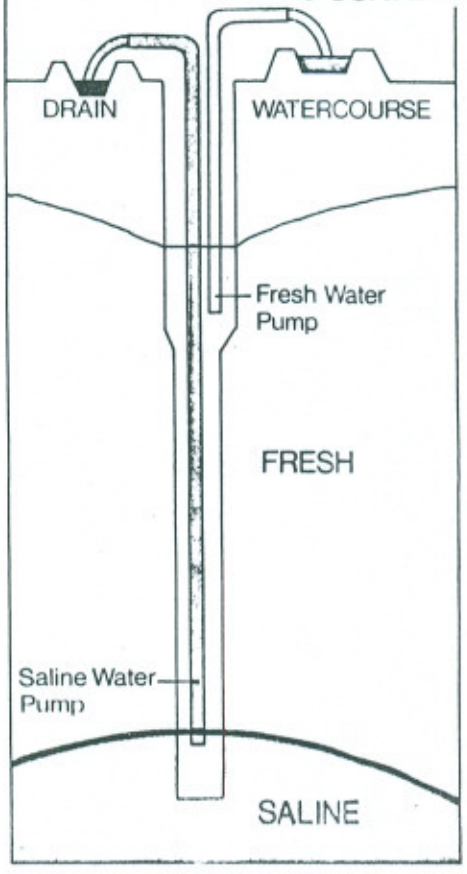
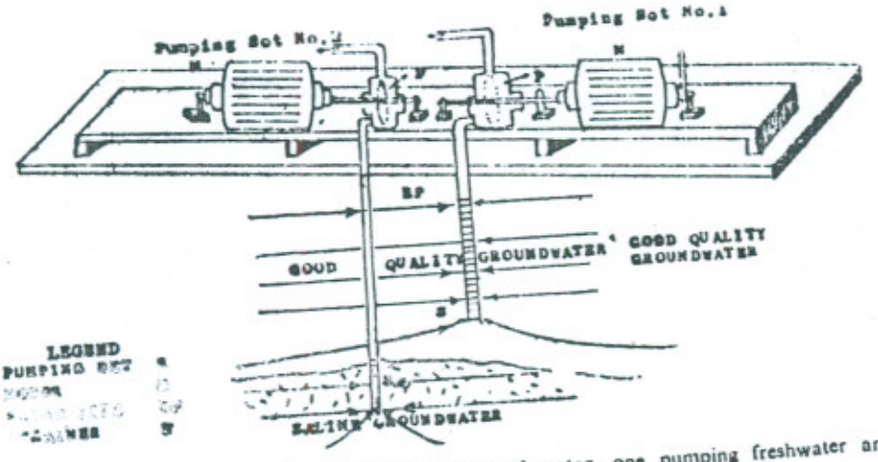


Figure- 2(a)



Compound tubewells with separate pump and motor, one pumping freshwater and the second saline groundwater.

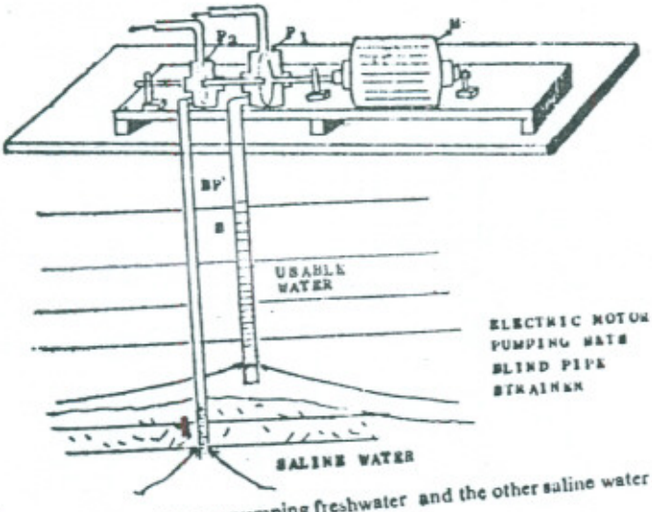


Figure-2 (b) –Two tubewells, one pumping freshwater and the other saline water operated by the same motor.

Data of several bores on the left side of the Indus having considerable depth of usable water is contained in the book on Groundwater Resources of Pakistan. Examination of results of these bores indicate that in nearly 60 percent of the bores usable water can be withdrawn by proper type of skimming, shallow, multiple strainers, well point type or compound tubewells.

3.4 Compound or Scavenger Type Tubewells

If at a site a clay layer of a suitable thickness located at a suitable depth is not found and fresh water aquifer is too thin even to install multiple strainer tubewells then compound tubewell can be a solution but not of the type as being proposed aby Huntings (Scavenger type see Fig.I), as the provision of a submersible pump and the main tubewell provided with turbine pump, not only the cost will increase, the extraction of very shallow depth of fresh water may become a problem. Actually it should be the duty of the Research Organizations of Pakistan to test various alternatives and design. In our view a centrifugal pump is for superior even to extract thin fresh water layer and with single or multiple strainers to deal with saline groundwater. (See Fig-2(a) & (b). A centrifugal pumping set cost Rs.6 to 10 thousand against a submersible pump of Rs. 80 thousand and a turbine pump of the same order of cost.

4. Pumping Deep Saline Groundwater and Its Defects

About 40 percent of saline groundwater area is such on which either the layer of fresh water is nominal or it is out of the patch where the saline water starts from the top surface. Actually there are several pockets of saline groundwater varying between 1000 to 2000 ppm located close to the surface. These areas are either part of saline groundwater zone with high order of salinity existing at deeper depths or are located at shallow depths only. We have been proposing that in order to provide damage to these saline groundwater pockets, we should install shallow multiple strainer tubewells of maximum depth of 50 ft or even less. At these sites with surface recharge of 1.5 feet per unit area per year, and top water quality to a maximum of 2000 to 5000 feet, it will be possible to dispose off water of this quality to a drain, a canal or a river and with 0.85 cusec of recharge per square mile with possibility of mixing this fresh water and improving the water quality after some times. At present we are installing deep high capacity tubewells pumping highly saline water, the disposal of which is a problem. In Allahabad Project of SCARP 6, 250 high capacity tubewells are being intalled the water of which will be disposed through open drains into ponds covering an area of 60,000 acres. The saline water will be either evaporated or seeped under ground. The same is the proposal for draining into the LBOD in Sind. Open drains are most difficult to be maintained.

TABLE–17(Cont.)
VARIATION OF GROUNDWATER QUALITY WITH DEPTH FOR SING (WITHIN THE 0–5 AREA)
Data from L.I. Report.

Sr. No.	Well No.	Depth (ft)	TDS (ppm)	Sr. No.	Well No.	Depth (ft)	TDS (ppm)
1.	LIPW-138	44-55	1720	6.	GR-20	150	270
		170-180	6790				
		264-274	13400	7.	BH-50	87	1650
		404-414	18360			107	2380
		564-574	16500			139	2900
						170	2695
2.	GR-19	150	1920				
				8.	LIPW-133	44-54	1010
3.	GR-17	150	400			144-154	1710
						262-272	1650
4.	lipw-130	41-97	372			412-422	4660
		200-210	540			540-550	13200
		350-360	680				
		418-428	912	9.	GR-14	150	360
5.	GR-16	150	440	10.	GR-22	150	1400
				11.	GR-21	150	320

It is worth while to check the condition of existing drains in the area of Kotri Barrage. These are all flat drains with extensive weeds growth. There is a great possibility for the highly saline groundwater brought to surface to seep around and thus spoil the surface soil. We shall ever be spending power to pump useless water. We should not only waste the persistant percolation of 0.85 cusec per sq. mile from irrigation operation and whatever thin layer of low salinity water exist at top will also be wasted. Besides these persistant ever lasting defects we are obliged to spend heavily on construction and maintenace of tubewells. According to new programme of installing tubewells in saline groundwater constructing 1700 tubewells by 1987-88, the estimated

cost is Rs. 1345.46 million. By 1991-92 2842 tubewells are to be finally installed and their cost estimate is Rs.2543.60 million. The details of yearly installation and their rising cost due to escalation is accounted for in Table–18 below

TABLE–18
CONSTRUCTION COST OF SGW TUBEWELL AND THEIR O&M COST

1. Installation Cost of Public Tubewells in Saline Groundwater Zone.

Year	No. of T/W to be Installed	Installation Cost per Tubewell (Million Rs.)	Total Cost Million Rs.)
1983-84	2842	0.702	1995.08

If the tubewells are Installed under Phased Programme 340 each year starting 1983-84 and finishing by 1991-92, the cost estimate is:

1991-92	2842	1.119	2543.00

Escalation rate is 7.5% during 1981-84 and 6% thereafter.

2. O & M Cost of SGW T/W in Punjab

Punjab	No. of SGW T/Well	O&M Cost per T/Well Per Year (Rs.1000)	O&M Cost in Rs.Million
1983-84	1070	56.22	60.16
1987-88	1070	70.98	75.95
		TOTAL	136.11

Not only we have to spend Rs.254.36 on their construction, their opeation and maintence cost by 1987-88 for 1534 tubewells installed in saline groundwater upto 1981-82 is estimated at Rs.10.074 crores.In the Punjab by 1981-82, SGW tubewells number 1070 and O&M cost of which by 1987-88 is estimated at 7.6 crores and 1360 tubewells are proposed to be installed by 1987-88 O&M cost of which is Rs. 8.932 Million, thus by the end of 6th plan Punjab shall have to spend Rs.16.532 crores on maintenance of tubewells pumping useless water. If proposals as put forth by us are adopted instead of 2842 tubewells each of 3 cusecs the total pumpage of which is 8526 cusecs, suppose we put in one cusec tubewell with three strainers each, cost for one such tubewell with centrifugal pump is Rs. one lakh at the most. To pump 8526 cusecs from one cusec capacity tubewell the cost. is Rs.852.6 million against 2543.6 million of tubewells being installed.

According to our studies, out of the saline groundwater area of the Punjab and Sind, 60 percent of 16.7 maf amounting to nearly 10 maf can be recovered by skimming type tube-wells and 40 percent of 16.7 maf i.e. about 6.7 maf will become recoverable after a few years of pumping of thin 50 ft thick saline groundwater area. With this technique we eliminate all the defects enumerated before while pumping saline groundwater.

5. Our Suggestions need serious consideration:

In 1960 we submitted a joint paper based upon the information then available on the design of tubewells, their capacity, material of construction and their advantages. Nobody gave attention to our recommendations. The results of tubewell construction in SCARPs are now obvious. now the Government wants to get rid of their construction and wants to replace them with the design we recommended. In this paper we kindly want to bring it on records that the present action of pumping saline groundwater and its disposal is disastrous for the country. God has saved up from the manace of saline groundwater and pushed it too far down causing no harm to the dewellers but now we want to bring this poison on the surface of land and create such harmful conditions so that our generations will ever repent on this action. Let us not pump out the deep poison. Let us keep the top 30 to 50 feet of soil free of salts, recover 16.7 maf of fresh usable water, make reservoir in the underground formation to store fresh wsater recharge. We have not the power nor the finances available to pump unfit useless deep located saline groundwater, nor can we bear the loss of 16.7 maf of fresh usable water. We are not so rich as to adopt costly means of pumping useless water. Has not the farmers shown us the lead that they can pump one or two cusecs with an expenditure of Rs. 35,000/-. Why should the public funds be used to pump 2 to 3 cusecs with ten times their expenditure on tubewells alone and twenty times their expenditure water an pushed it too far down causing no harm to the dewellers but now we want to bring this poison on the surface of land and create such harmful conditions so that our generations will ever repent on this action. Let us not pump out the deep poison. Let us keep the top 30 to 50 feet of soil free of salts, recover 16.7 maf of fresh usable water, make reservoir in the underground formation to store fresh water recharge. We have not the power nor the finances available to pump unfit useless deep located saline groundwater, nor can we bear the loss of 16.7 maf of fresh usaable water. We are not so rich as to adopt costly means of pumping useless water. Has

not the farmers shown us the lead that they can pump one or two cusec with an expenditure of Rs.35,000/-. Why should the public funds be used to pump 2 to 3 cusecs with ten times their expenditure on tubewells alone and twenty times their expenditure if electric charges are also included. World Bank cost estimates of such a tubewell at Rs.6 lakhs whereas the farmers complete their tubewell with Rs.35,000/-.

6. Saving Water Lost by Evaporation

From Shewan and Kinjar Lakes we lose about 1800 Cs. and from Hub Dam another 500 Cs. by evaporation. Many experiments with chemicals to produce monomolecular films to reduce evaporation have been conducted. We have not conducted any experiment so far in the field. It is suggested that we may experiment by applying cover on the surface of water and check its performance. It is suggested that if floats 5 ft. apart are fixed on the surface and a film of black visquien type is spread on the float, its action is worth investigation. The film can be spread at any suitable height and its result on reduction of evaporation is worth a trial. Instead of the film white packing material 'Thampore' can also be experimented upon. We have put forth this suggestion to point out the urgency of conducting experiments on reduction of evaporation.Time is coming when we shall have to save water wherever possible.

Summary of Basic Conclusions

1. Pakistan possesses water resources both of surface streams and groundwater. Indus system is the main river which passes on the average 142 maf in a year.

2. During the last 38 years diversion of water into the various canals system has continued to be increased from 54.42 maf in 1940 to 102.68 maf in 1978. Still about 40 to 46 maf of water runs off to sea every year.

3. In order to conserve some of the summer flows, Pakistan has built two dams, Mangla on the Jhelum and Tarbela on the Indus. This has started affecting the sailaba lands along the rivers. The effect on such lands along the Sutlej and Ravi, water of which has been diverted for use in India, is more serious.

4. Pakistan is facing shortage of water. One example is that of Karachi which depends upon the diversion of water of the Indus River into Kanjar (Kalri) Lake. This water is insufficient to fulfil the needs of the expanding city. There is sufficient water going waste below Kotri for several summer months. It is possible to find a sutiable site below kotri on the river Indus from which the water could be lifted and carried through channels to Karachi. This water is sufficient for all future needs of Karachi for several months in a year. During the period river flow below Kotri is stoped, the storage of Kanjar Lake will start to be utilized. Besides this there exists a possibility of fresh water seepage in the bed of the river, withdrawal of which can further ease the position for several months.

5. The active flood plains and the salaba lands which now receive flood spills very infrequently, do possess usable fresh water close to surface which can be extracted by tubewells for use on land free of salinity problems. This groundwater will continue to receive recharge not only during flood season but also during the low supplies from the perennial source.

6. Groundwater is an important source of water available to Pakistan. In the Indus Plains with a diversion of nearly 96 maf during 1977-78, into canals about 46.0 maf seeped into the underground formation. It was estimated that 4.3 maf in the Punjab and 12.4 maf in Sind out of the fresh water seepage was added to the formation said to possess saline groundwater.

7. Examination of the groundwater quality along depths in saline water zones has indicated that nearly 60 percent of this area possesses fresh usable groundwater in sufficient depths to be extracted by suitable type of multiple strainer or shallow well point type tubewells. It is estimated that nearly 10.0 maf of usable water can be withdrawn from this zone.

8. The rest 40 percent of the saline groundwater zone possesses thin fresh water at top and also receives surface seepage. The top 40 to 50 feet depth of water thus possesses salinity in the range of 2 to 3 thousand ppm. If shallow multiple strainer tubewells are installed in the depth the pumped water will not be too saline. Its disposal will be possible without much problem and after a limited period possibility of replacement and improvement of saline groundwater also exists.

9. Presently the saline groundwater is being pumped by deep high capacity tubewells and is disposed into drains, rivers or evaporation tanks spread on nearly 60,000 acres. The transport of this highly saline water through surface drains can spread salinity on surface soil. The LBOD is also being constructed on the same principle to pump deep located saline groundwater from the zone of Nara canal and southern Rohri and dispose it by LBOD.

10. In certain area of Nara Canal it is proposed to install a number of scavenger type compound tubewells provided with submersible and turbine pump. It is possible to install instead centrifugal pumps, the cost of which is 1/8 to 1/10 of the submersible6turbine pumps.

11. About 2842 tubewells are to be installed to pump saline groundwater at a cost of Rs.2543.6 millions. If one cusec tubewells operated by centrifugal pumps are installed, the cost to pump the same amount of water will come down to Rs. 852.6 millions.

12. The Punjab spent Rs. 7.6 crores during 1981-82 on O&M of 1070 tubewells. By 1987-88 on the O&M of 1360 additional tubewells the cost will be Rs.8.93 crores. Thus Rs. 16.32 crores shall have to be spent annually to pump useless water.

13. A last proposal is to save a part of large volume of water presently being lost through evaporations. Nearly 30 maf of water is lost from the water surface of our canals systems and rivers. About 6.0 maf is lost from big and small storages, lakes and ponds and 4.0 maf is lost from soil with water table within 5 feet.

14. We propose to save a part of evaporation from ponds, lakes and storages by spreading plastic sheets on the surface of lakes with high evaporation. The soil evaporation from high water table can be reduced by pumping groundwater and lowering the water table.

15. These are a few of our suggestions aimed at saving and improving water resources of Pakistan.

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