PAKISTAN

ABSTRACT

Water is a precious commodity that is to be maintained in its natural form. A little rise in glacier melts where from most of the Rivers take their major flows might drown entire habitat of earth. Pakistan has 16-Mha Irrigated agriculture, which is depending on a total of 173 Bm^3 of water. The waterlogging and salinity, theft of canal water, over-exploitation of fresh groundwater, low efficiency in delivery and use, inequitable distribution, inadequate maintenance and inefficient cost recovery have been recognised as main problems of Pakistan's Irrigation System.

The present population of Pakistan is 130 millions out of which rural population is 67.5%, which by the year 2010 would rise to 175 millions. In order to be self reliant in agriculture, the yields are to be increased by 50%, cropping intensity is to be maintained to the level of150% and additional area of 2Mha is to be brought under irrigation command. The water resources engineers and planners find a great economical advantage in the storage of some part of non-utilized 28.83 Bm^3 in some suitable reservoirs. Proposals for construction of a replacement dam on the main Indus, and increasing the height of Mangla dam over River Jhelum are actively considered. However aquifers are not seriously considered though they are environment-friendly and offer better under ground storage at lesser cost.

It is recommended that new alternatives should be worked out to stagger the summer peaks and rejuvenation of silted reservoirs. The programs involving field drainage, transition of tube wells to the private sector, lining of tertiary canals in the saline ground water zone, improved irrigation methods, appropriate cropping pattern and water pricing mechanism, should be taken as key factors for the prosperity of irrigated agriculture and rural areas of Pakistan.

INTRODUCTION

Water is a precious gift of Mother Nature that is to be maintained in its natural form. Though its 97.5% stays in the oceans, and the 2.5% is fresh (Shiklomanov, 1998), the 0.26 % of the total amount of fresh water is enough to meet the requirement of this globe. If the temperatures were to rise a little due to man made interference, little more melts out of 2.5% fresh water would cause such devastating floods and rise in water level that entire habitat of earth could be submerged.

Pakistan is basically an agricultural country whose agriculture mostly depends on irrigation. Out of its total area of 79.61 Million hectares (Mha), forests are on 3.44 Mha while irrigated agriculture is spread over 16 Mha. The country lies in the arid or semi-arid part of the world between 24°N and 37°N latitude and between 61°E and 77°45_E longitude. Though most part of the country has an arid climate, Indus River system compensates its water shortage. The rivers have their origin in the higher altitudes and derive their flows primarily from snowmelt and then from monsoon rains. The irrigation management in Pakistan plays a vital role in most of the development programs. However the availability of irrigation water at the time when plants require also is equally important.

It has been observed world over that even if water supplies were derived from storage reservoirs; unforeseeable events often disrupted original service targets (Perry, and Narayanamurthy; 1998). The misuse of irrigation water not only has deprived another legitimate user but also has created the problem of waterlogging and secondary salinity at the places even away from the place of its misuse. The World Bank identifies, waterlogging and salinity, theft of canal water, over-exploitation of fresh groundwater, low efficiency in delivery and use, inequitable distribution, inadequate maintenance and inefficient cost recovery as the main problems of Pakistan's Irrigation System (World Bank, 1994). Thus new strategies are to be adopted to improve water and soil management aiming at water savings, conservation of ground water resources and increased yields.

It can be very well imagined that the livelihood of rural population is mainly on agriculture where small home dairy used to be a co-subsistence job. Due to presence of animals, the farming community had an urge for crop rotation with fodder crops like sorghum, maize, alfalfa, clover, and some leguminous crops. In order to increase cultivation intensity, timelines in sowing and harvesting became a favorable factor for adaptation of mechanized cultivation. But due to small land-holdings, only big landowners and others who extended farm machinery services on rental basis could purchase tractor and implements. Unfortunately, the lack of expertise and non-existence of user organizations created a vacuum of accountability so that the rental works became quite sub-standard. As a result, shallow tillage, increased soil compaction, and poor land drainage deterred any significant increased in crop yields.

The cardinal principles of irrigation distribution in Pakistan have a legacy of British colonial era when population was less and investments on development works were probably assigned short recovery period. The irrigation distribution was therefore designed to cover maximum area. In most of the perennial systems, the allocation of water at the outlet was designed for a cropping intensity of 25 and 50 percent for Rabi (winter) and Kharif (summer) cropping respectively. About 210 l/s were allocated for 1000 ha (1.8 mm/day) for this 75% intensity, which was forcing the farmer to leave 75% fallow in Rabi and 50% in Kharif for preparation of next season crop and sun bathing. The non-perennial canals were allocated about 1330 l/s for 1000ha for rice cultivation, which was equivalent to 8.64 mm/day for 100% cultivation in a single season. The operation of the system is still based on a continuously running fixed rotational supply system, which is closed only for one moth of winter to desilt the canals. The supply to canals is also stopped during peak of floods so that silt does not enter the canal systems.

NINTH FIVE-YEAR PLAN (1998-2003)

This plan emphasizes on management cum development package for water resources through conservation, high efficiency irrigation systems, conjunctive use of surface and ground water, and on development of new or replacement reservoirs. It is a continuation of the 8th five-year (1993-1998), which was aimed at progressive additions to irrigation supply from new surface irrigation schemes, transition of tubewells from public to private sector, improvement and management of existing irrigation system, and protection of lands and infrastructure from waterlogging, salinity and floods.

The 9th five-year plan promotes efficient irrigation techniques, encourages multi-objective scientific reservoir operation for irrigation, flood control and hydel power generation. It also includes affirmative action with respect to non-classical areas such as private partner ship, participatory development, good governance, environment protection, and water legislation. It envisages to generate 4.32 MAF of water by conserving measures and installation of tubewells; to reclaim1.21 ha of disastrous area under National Drainage Program (NDP), and to construct at least one major reservoir.

WATER AND AGRICULTURE IN THE YEAR 2010

The population of Pakistan in 1998 has been increased by a growth rate of 2.61%. The strength of rural population is 67.5% with a 6.6 house hold size and feminine gender as 32% of total population (Population & Housing Census of Pakistan, 1998). Looking into population reduction from 3.66% in 1981 to 2.61% in 1998, the projected population by the year 2010 would be 175 millions. As the economy of Pakistan mainly depends on the prosperity of its irrigated agriculture, first of all the agriculture and water sectors should be made self-sustained and then further export oriented advancements could be planned. In Table 1, it can be seen that with the present yield trends, country would require 40.44 Mha of land and 256.6 Bm^3 of water.

FOOD AND WATER REQUIREMENTS.

By the year 2010, the water requirement for the domestic purpose at an average consumption rate of 100 l/capita would be 6.4 Bm^3. Taking at least the same volume for Industrial sector, non agricultural demand would be about 13 Bm^3. The demand for agricultural sector has been projected via Table 1, which goes for a supply of 257 Bm^3, against a combined supply of 203 Bm^3 from surface and ground water resources at the farm gate (Table 3). Thus 33% of yield increase is to be achieved within next 11 years at annual growth rate of 3%. This increase would none the less require 190% cropping intensity, which virtually would give no time for keeping land fallow. Alternatively if yields were increased by a growth rate of 3.8%, 50% increase in yields could have achieved up to the year 2010. For this alternative, crop water requirement would be 171 Bm^3 and cropping intensity 169% but it might put the land under the pathogenic and fertility stresses. It would therefore be more desirable to keep cropping intensity to 150% and bring another area of 2Mha under irrigation command.

WATER RESOURCES

The surface flow from the Indus River System (IRS) is the main source of water supply in the Indus valley. Though the ground water makes a modest contribution at the farm gates yet it takes its origin from the seepage of the conveyance system, and percolation from fields and rainfall excessive to the water holding capacity of the soil.

Table 1. Land and Water Requirement for the Year 2010 (Population: 175M)

Commodity	Commodity Individual Kg	Requirements Total M t	Crop Delta.@ Farm Gate (m)	Agri. Yields t/ha	Requirements Land (Mha)	Requirements Water (Bm^3)
Wheat	138	24.15	0.5	2.1	11.50	57.50
Rice	23	4.03	1.17	1.83	2.20	25.73
Maize	10	1.75	1	0.6	2.92	29.17
Pulses	7	1.23	0.37	0.58	2.11	7.81
Other Grains	5	0.88	0.3	0.52	1.68	5.05
Fruits	59	10.33	2	12	0.86	17.21
Vegetables	45	7.88	1	7.5	1.05	10.50
Sugarcane	338	59.15	1.3	46.9	1.26	16.38
Oil Seeds	68	11.90	0.4	1	11.90	47.60
Cotton	17	2.98	0.8	0.6	4.96	39.67
Total					40.44	256.647

Surface Water: The Indus Basin covers 70% of the country's area, and forms the major water source (Document of the World Bank, 1994). The post Tarbella (1976-77 to 1994-95) record of IRS is illustrated via Figure 1, which shows that mean annual flow at rim stations is 163.68 and 10.61 Bm^3 from Western and Eastern Rivers respectively. However the means from 1937-38 to 1994-195, yield the annual flows of 167.67 and 20.34 Bm^3. Logically the present situation of flow would be based on historical record of Indus and post Tarbella record of Eastern Rivers, which is 167.67 and 10.61 Bm^3. The contribution of about 7 Bm^3 form small rivers Soan and Haro should also be added for proper water accounting.

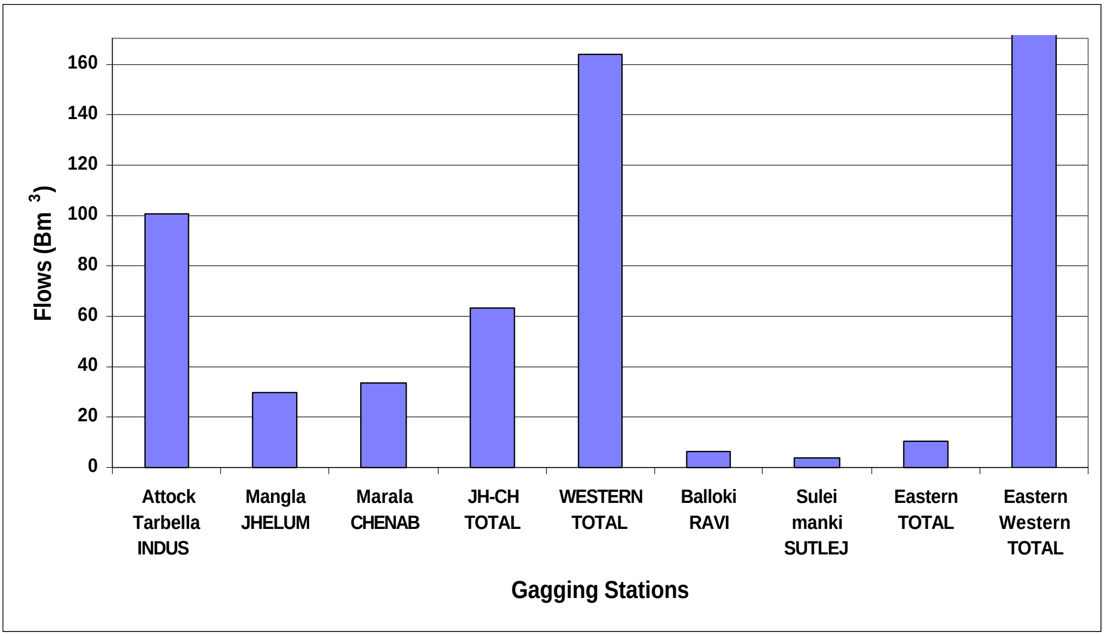

Figure 1. Surface flows in the IRS (Bm^3) from 1876-77 to 1994-95

The mean monthly flows in the main Indus are shown in Table 2. It can be seen that 78% of flow takes place in five months from May through September. Consequently the dependable supply based on Western Rivers is presented in Table 3. The water accounting shows that water consumption in this country is at equilibrium with mean annual supply. For a population of 175 millions and above the annual availability of water would remain below 869 m^3 per capita. It appears that on one hand the water resources of the country are fixed and are mostly exploited, then on the other hand the demand is on a permanent rise. The decision-makers have thus no choice but to increase the water use efficiency of crops to help achieve sustainability in the agriculture and water sectors.

Table 2. Mean Monthly Flows in The Indus (Bm3) From 1940-41 To 1996-97

MONTH	Mandori		Kalabagh		Sukkur		Kotri	
	(Bm^3)	%	(Bm^3)	%	(Bm^3)	%	(Bm^3)	%
JAN	2.51	2%	2.25	2%	1.29	1%	1.32	2%
FEB	2.76	2%	2.31	2%	0.46	1%	0.65	1%
MAR	3.63	3%	3.08	3%	0.81	1%	0.73	1%
APR	5.58	5%	4.75	4%	2.55	3%	2.06	3%
MAY	10.25	9%	9	8%	5.21	6%	4.23	5%
JUN	19.06	16%	16.9	16%	9.61	10%	7.16	9%
JUL	26.32	23%	24.4	23%	21.78	24%	15.9	20%
AUG	23.81	20%	23.1	22%	31.57	34%	26.9	34%
SEP	11.28	10%	11	10%	13.66	15%	14.7	19%
OCT	5.24	4%	4.53	4%	3.27	4%	4	5%
NOV	3.28	3%	2.74	3%	0.75	1%	1.17	1%
DEC	2.9	2%	2.37	2%	0.67	1%	0.78	1%
TOTAL	116.6	100%	106	100%	91.63	100%	79.6	100%

Table 3. Average Annually Possible Availability of Water at Farm Gate

	Source	Bm^3
A	Water in Indus system at Rim Stations	173
B	Direct precipitation	49
C	Total Available (A+B)	222
D	Evaporation Losses @ 10% of (C)	22
E	Deep percolation @ 4% of (C)	9
F	Seepage from conveyance @15% of (A)	26
G	Water release downstream Kotri	12
H	Surface Water at Farm gate (C-D-E-F-G)	153
I	Groundwater supply	53
J	Total at the Farm	206
K	Non Agricultural Demands	9
L	Field Losses @ 30% of (J)	62
M	Leaching @15% of (J)	31
N	Total for crop use (J-K-L)	135
O	Ground Water Potential (F+L-I-M)	4

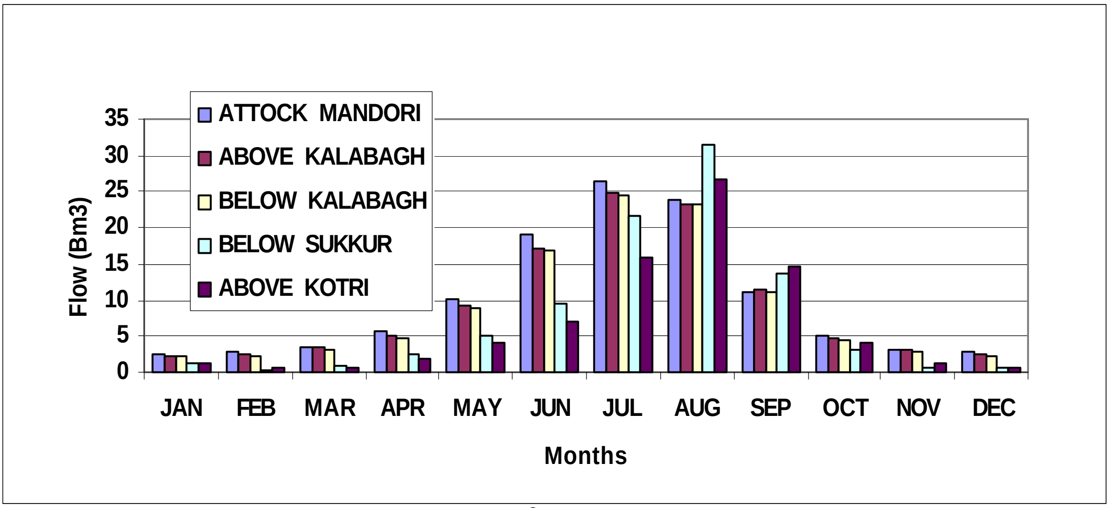

Figure 2. Mean monthly flow (Bm^3) in Indus from 1940-41 to 1996-97

Ground Water : It is very important renewable resource of Pakistan. The Indus basin has a huge unconfined aquifer, which presently contributes about 53 Bm^3 but at the sea level depth it is invariably underlain by seawater. Its main source is seepage from irrigation conveyance system and percolation from the irrigation fields. In seventies when population of the country was less, the concern of public sector was to lower down the groundwater through drainage wells. But with the increase in population, increased food demand brought in the investments of private sector to pump out the fresh ground water to meet with the deficiencies of irrigation at critical stages of crop growth. Out of an annual ground water withdrawal of 53 Bm^3, the private sector is now pumping about 45Bm^3 through small size tube wells.

Over the last three decades about 13500 saline tubewells have been installed in the public sector over a gross area of about 3.7 Mha. The use of ground water from public sector tube wells in fresh zones for irrigation purposes motivated the private sector to meet the irrigation deficits at critical growth stages through their own tubewells. Currently there are over 450,00 private tube wells installed for irrigation purposes. There are estimates on ground water discharge and recharge, one of them shows that the groundwater pumpage in the Indus Basin has reached to 59 Bm^3 in 1996-97, out of which 47 Bm^3 are contributed from private tubewells. The estimated usable groundwater potential is suggested about 66 Bm^3, leaving an unused balance of about 7 Bm^3.

Since there is a gap of 21 Bm^3, any miscalculated abstraction of groundwater would lead to ground water mining and its degradation from salt-water upcoming and encroachment. Thus further analysis was made to find out the impact of various permutations of evaporation, deep percolation, seepage, and field losses on the net availability of water for crop at the farm and for additional ground water potential (Table 4). The basis of calculation is that total flow to the IRS is 222 Bm^3 and ground water pumpage is 53 Bm^3.The above table illustrates that quantum of ground water can be increased through saving of non-recoverable losses like evaporation and

Table 4. Effect of Water Loss Parameters on Availability of Water for Crops

Losses (%)				Available Water (Bm^3)	
Evaporation	Deep Percolation	Seepage	Field	Net For Crops	FGW Potential
10%	4%	15%	30%	144.2	3.8
10%	2%	15%	30%	147.3	4.5
10%	0%	15%	30%	150.4	5.2
10%	0%	12.5%	30%	153.4	1.5
10%	0%	17.5%	30%	147.4	8.9
10%	0%	20%	30%	144.3	12.5
10%	2%	20%	30%	141.2	11.9
7.50%	0%	20%	30%	148.2	13.4
7.50%	0%	20%	35%	137.6	24.0
10%	4%	15%	35%	133.9	14.1
10%	2%	15%	35%	136.8	15.0
10%	0%	15%	35%	139.7	15.9
10%	0%	12.5%	35%	142.5	12.5
10%	0%	17.5%	35%	136.8	19.4

deep percolation. Where as by making saving in seepage, ground water potential is reduced, saving in the field loss would only redistribute the flow between crops and ground water potential. Thus one should be aware of the fact that indiscriminate pumping without proper monitoring mechanism and lack of knowledge of chemistry and hydrodynamics of aquifer would be causing up coning of saline ground water. It is feared that aquifer is already polluted because the salinity of tubewells has increased at many places. In addition to that terming the water of 1000-ppm salt content as fresh is encouraging pumping of saline water. For agriculture purpose, water is called fresh when its EC is less than 1500 micro mhos, SAR is less than 10 and RSP is less than 2.5 (NESPAK et al, 1993). In the absence any channel of salt pickup and its removal from the project area, a continuous accumulation of salts at the soil surface and underlying root zone would be taking place. Ground water pumping should be integrated with equity between incoming and outgoing salts. Provision of artificial recharge to ground water especially during floods should be made to compensate the total pumping with its recharge.

RESERVOIRS

The sustainability of the irrigation and agriculture systems is mainly dependent on the actual flow of the rivers taking place in 5 months of high summer. Thus to stagger the peak summer flows three surface reservoirs have been constructed in the past. The Mangla reservoir was constructed in 1967 on River Jhelum for a live storage capacity of 6.6 Bm^3, whereas Chashma and Tarbella were constructed on main Indus in 1971 and1975 for 0.6 Bm^3 and 11.5 Bm^3 respectively. After a passage of two and half decades not only the storage capacity of existing reservoirs has been decreased by 22% but also the population has increased more than100%. As a result a dire need has arisen to build replacement reservoirs as well as some additional ones to help enhance the operational flexibility of available water resources in the deficit periods. The 35-year pre-Tarbella data (Table 5) from 1962-63 to 1996-97 shows that mean annual flow downstream Kotri is 53.42 Bm^3. The 21-year (1976-77 to 1996-97) post-Tarbella data also show a 51.74 Bm^3 flow downstream Kotri. The policy makers of the country foresee a serious food crisis, and cannot justify the escape of average annual flow of 51.74 Bm^3 downstream of Kotri. Taking out the average annual contribution of 10.61 Bm^3 from Eastern Rivers and the committed down-stream Kotri flow of 12.3 Bm^3 volume, the water resources engineers and planners find a great economical advantage in the storage 28.83 Bm^3 in some suitable reservoirs.

Table 5. Post- and Pre - Tarbella Mean Flows in the Indus River

	Gagging Stations									
	Attock		Above Kalabagh		Above Guddu		Above Sukkur		Below Kotri	
	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre
Season	21-Yr	35-Yr	21-Yr	35-Yr	21-Yr	35-Yr	21-Yr	35-Yr	21-Yr	35-Yr
	Flow (Bm^3)									
Kharif	95.0	95.3	83.4	85.3	101.9	101.6	92.9	92.3	48.6	50.7
Rabi	28.6	23.1	24.1	20.6	21.2	18.8	18.6	17.1	3.1	2.8
Annual	123.6	118.4	107.5	105.8	123.1	120.4	111.6	109.4	51.7	53.4

The hydro-geological and topographical conditions of the country favour construction of new reservoirs only on the Indus River. The Post-Tarbella (1977-78 to 1990-91) record also shows an unused escape of 18.71 Bm^3 down stream Panjnad. This much volume of non-utilised flow cannot be overlooked now. In addition to that, flow in the River Jhelum (Figure 4) indicates that there are some occasions when annual flows are much lower than the mean values of 24.83 Bm^3. Under such circumstances a supplementing alternative could be evaluated whether or not height of Mangla dam could be raised to add the storage capacity of the reservoir and to generate its power potential. This proposal would further ensure the guaranteed supply from the Mangla reservoir because storage from preceding year surplus flows, would help mitigate floods in Punjab and minimise escape of flood water downstream Panjnad.

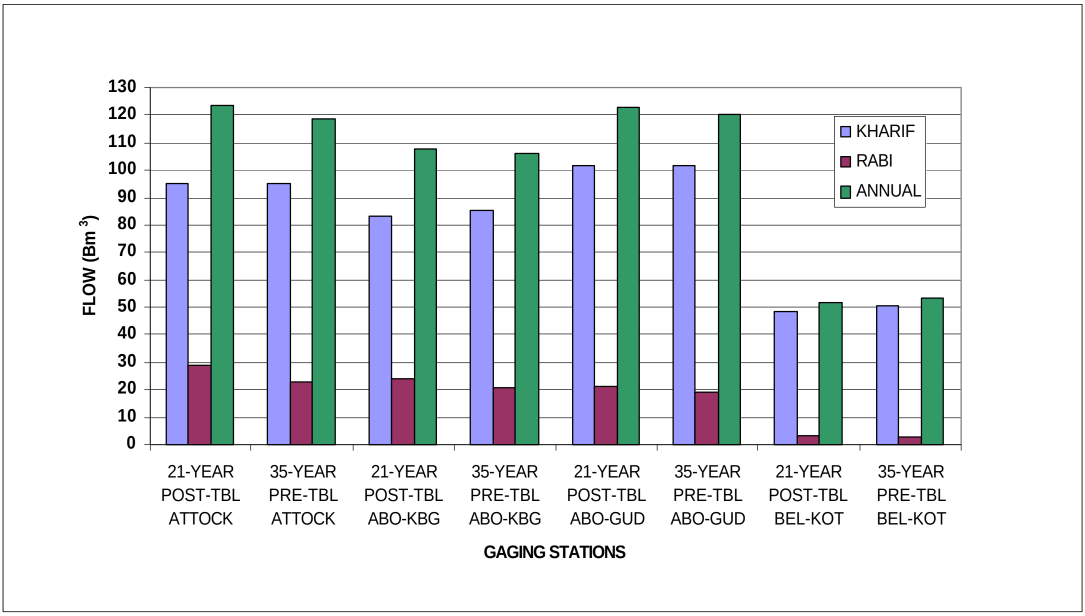

Figure 3. Post-Tarbella and Pre-Tarbella Indus flows (Bm^3)

Till now full attention has been focussed on surface reservoirs though the ground water reservoir (aquifer) has much more storage capability at lesser cost and in an environment friendly atmosphere. As the aquifers are prone to pollution by salt-water intrusion when groundwater is being mined, it is more important to store floodwater through artificial recharge. It is highly advantageous to simulate the ground water pumping conditions with shallow partially penetrating skimming wells (Chandio and Larock,1984; Chandio and Chandio,1992). But restraint should also be applied against the accumulation of salts in the agricultural fields.

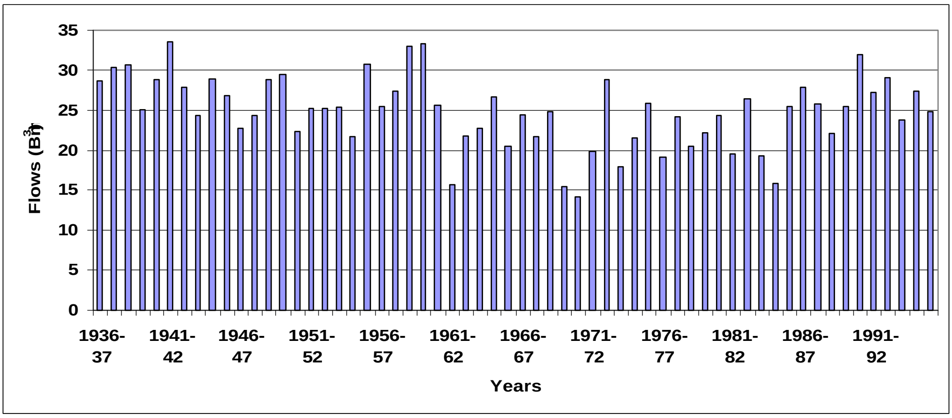

Figure 4. Mean annual flows in river Jhelum from 1936-37 to 1994-95

WATER MANAGEMENT

Field Drainage

Drainage is the main concern of irrigated agriculture in the world. Management and disposal of drainage water is though an expensive challenge but it is rewarding because it helps increase the crop yields to a greater extent. In order to achieve 50% increase in agricultural yields, drainage is the main tool but it should be properly inter-linked with disposal of effluent out side the irrigation command. The Government of Pakistan initiated the construction of Salinity Control and Reclamation Projects (SCARPs) in early sixty's. Because the initial investment was considered a decisive factor, tube well technology for drainage was favored. Latter on the heavy operational and repair costs, and pumping of saline water from under ground brackish water zone tilted the balance in favor of shallow tube wells or even pipe drainage system. The tubewells have contributed to the salt accumulation in the soil surface because the equality between incoming and outgoing salts was not maintained and the water table virtually lowered by evaporation and transpiration only (Shaikh 1992).

By June 1995, SCARPs completed drainage facilities in a gross area of 6.02 Mha at a cost of Rs 25 billion. In addition to that new projects were undertaken over an area of 2.96 Mha at a cost of Rs 42 billions. However, the monitoring of the completed projects indicated that some of them have failed to deliver their expected results so much so that about 2.02 to 2.42 Mha of irrigated area persistently remained under high watertable. In view of that scenario, the National Drainage Program (NDP) was approved in 1997 for a total cost of Rs 31.4 billions.

Table 6. Summary of The Major Project Activities in NDP-I

	Integrated Irrigation and Drainage Programs				Drainage Programs		
Nature of projects/ schemes	Drainage and irrigation	Canal remode-lling	Intercept or drains	FGW tube-wells	Surface drains	Tile drainage	SGW tube-wells
	Size						
New	225400 ha	347 Km	269 Km		77 Km	10500 ha	
Off-Farm	Rehabilitation/ Remodeling of Existing				3173 Km		
Drainage	Extension of Existing				925 Km		
and	Rehabilitation and Replacement			6296 Km	34000 ha	863	
O&M	O&M through Performance Contract				7703 Km		
On-Farm Drainage	Transfer of Projects			1522 Tubewells			
	Transfer/ Construction/O&M			52740 Km		3745 ha	
Biological Control of Waterlogging						16400 ha	
Water Course Improvement/Lining in Saline Groundwater Area						500 Nos	

The NDP is another help to drainage sector but one may be genuinely afraid of its duplicity of previous engineering works, which have already shown a poor performance. The rehabilitation of saline ground water (SGW) tubewells may not be required if one wants to protect environment, and on farm surface drains may fail due to poor embankment stability, silting, weeding and land use problems. Similarly, interceptor drains would not be economical due to induced recycling of seepage water and indifference attitude of farmers to these drains. It would have been more appropriate to replace interceptor drains with field drains because each kilometer of interceptor drain could be surrogated by a 45-ha field drainage. The field drainage units could be handed over to the farmers without capital recovery with the condition that the user groups would not be provided with canal water, and the user groups would also bear all O&M costs. Following is the summary of proposed works:

In spite of all these efforts, about 6.5-Mha land would require field drainage facilities. This fact necessitates a continuous program of field drainage through shallow wells, tile drains, and surface drains, which should be well connected with out fall drains

Improved Irrigation Methods

In Pakistan, basin, furrow, and border irrigation methods are traditionally practiced; the basin method is most common. Due to higher field application efficiency, the drip, bubbler, and sprinkler irrigation methods have been introduced in Balochistan under International support programs but due to their expensiveness, they have not yet been adopted by the private sector. The National organisations like Pakistan Council of Research in Water Resources (PCRWR), and Pakistan Agriculture Research Council (PARC) are also making their research-based efforts to popularise these methods.

Experiments on vegetable crops conducted at the campus of Drainage Research Centre (DRC), Tandojam of the PCRWR show that on 12-year research basis, drip irrigation has 2.4 times higher water-use efficiency ratio over furrow irrigation. However, soil salinity increased in three years from 1.2 to 7.7 dS/m. It needed leaching after every three years but the rainfall automatically achieved the condition of leaching. The capital cost of drip is to the tune of US$ 5000/ha. It suggests that it could be introduced to orchards and higher priced vegetables.

The sprinkler irrigation method had 25 to 28% higher water use efficiency than basin method for cotton and wheat respectively. The capital cost of solid set system was about US$ 4000/ha. Both, the drip and sprinkler irrigation systems can be introduced to achieve higher water application efficiency at the places where irrigation tubewells are installed. Developing local manufacturing capability with some multi-national companies can reduce the capital cost of drip and sprinkler systems.

To minimise the conveyance losses, the On-Farm Water Management Departments are working on partial lining of water courses. As the pace of work is slow, piped watercourse of 45-cm internal diameter was tested to work under similar flow conditions to lined and earthen water courses. Its working was compared at a flow rate of 80 l/s wherein the piped watercourse had 21% saving in losses over earthen watercourse and 9% over lined watercourse, though both had same capital investment. The piped watercourse is working satisfactorily for about 9 years and up till now no repair and maintenance cost has been incurred on it.

Cropping Pattern

The land, water and climate play very important role in the adaptation of a cropping pattern, but traditions also affect the decision-making. It has been observed that many crops are grown in neglect to their appropriate environment. The water use efficiency is lowered down because of improper land levelling and due to water delivery on fixed rotation system. The banana and sugarcane growing has triggered water thefts because these crops require water more often than what does a fixed delivery system. Wherever banana is grown, it has become cause of high water table. Similarly cultivation of sugar cane is increasing all over the country, though the sucrose content and crop yield is very poor except in South. It is therefore proposed to introduce crop zoning and cropping pattern. The home dairy farming should be encouraged and leguminous and folder crops should be brought into crop rotation for better water use efficiency, nitrogen fixation, and weed control.

Water Pricing

The water pricing policies have a direct bearing on water equities. The traditional method levies water charges on the area of land cultivated irrespective of the volume being delivered at the farm gate. The landowners at the head reach of a watercourse always get water more than their share by depriving the ones at the tail of the same watercourse. In order to fill the gap between expenditure and revenues, water charges have been increased few times in the past but the revenue gap has not been bridged up. The Provincial Governments have created Provincial Irrigation and Drainage Authorities (PIDAs) but they have not yet delivered the goods in collection of more revenues.

The author is of the considered opinion that water metering should be introduced at all diversions where the in-charge of these units should be made responsible to collect the water charges according to volume of water passed under these structures. The irrigation authorities should be empowered to impose and collect heavy penalties on water thefts. This mechanism has been very successfully implemented in the energy sector where WAPDA management has been temporarily transferred to the Pakistan Army. The under-pricing of water and its inequitable distribution along with non-availability or violation of water rights are pushing the entire system to self-destruction.

RECOMMENDATIONS

The prosperity of Pakistan, especially its rural population is mainly attached with irrigated agriculture. The population might reach to 175 millions in the year 2010 that cannot be fed from prevailing agricultural system. Neither the land nor water is available to enhance the agricultural productivity through present poor rate of agricultural yields. The irrigation and drainage management is the key to break the slump in agriculture productivity. It is therefore recommended that :

1. The farming community should participate in the operation and revenue collection of the irrigation and drainage systems, and some portion of fresh tubewell should be disposed in the surface drains to maintain salinity equilibrium in the soil profile.
2. Lining of tertiary level canals in the saline ground water zone may be evaluated and their cost should be compared with the worth of water to be saved.
3. Additional Water storages including aquifers should be developed to stagger the peak flows of summer.
4. Possibility of raising the dam height of Mangla to increase the reservoir capacity should be explored to shave the flood peaks in the Punjab and to minimize escape of floodwater down stream Panjnad.
5. Disposal of drainage effluent should be routed to the sea.
6. Institutional reforms should be strengthened to enforce new water management policies and regulatory frameworks.

SUPPLEMENT DATA/INFORMATION ABOUT COUNTRY PAPER, (PAKISTAN)

The population of Pakistan, which is presently 130 million, is likely to reach the figure of 250 million by the year 2025. In order to meet the food requirements of ever-growing population it is necessary that available water resources should be properly planned, harnessed and managed. Their optimal use be made to bring additional barren lands under cultivation by providing proper irrigation facilities. Consequently increase per acre cropping yield. Pakistan receives some 146 MAF of water at rim stations out of which presently 106 MAF is used for irrigation purposes. The existing major storage reservoirs have a present capacity of 14 MAF. About 40 MAF is wasted due to lack of storage reservoir. This wastage of water can only be avoided by constructing additional storage reservoirs. Construction of new storage reservoirs (two Nos) will provide some 17 MAF of additional water. Besides this about 4 MAF water storage will be lost in the existing Tarbela & Mangla dams due to sedimentation and the net increase will be about 13 MAF. This water will be used to bring additional vergin Lands of 4 million hectares land under cultivation. Besides a saving of about 3 MAF can be achieved by improving irrigation infrastructure and by proper water management techniques. Thus optimal utilization of water resources and proper management at form level will ensure food and other rural development parameters by the year 2025. The projected Parameters of Pakistan related to Agriculture by the Year 2025 are given at next page.

S.No.	Item	Year 1998	Year 2025
1.	Population	130 Million	250 Million
2.	Water available at Canal heads	106 MAF	121 MAF
3.	Total area under Cultivation	17.2 Million ha	21.2 Million ha
4.	Yield (Irrigation area)	2.2 ton per ha	4.0 ton per ha
5.	Yield (Rain fed area)	1.5 ton per ha	2.2 ton per ha