WATER FOR AGRICULTURE AND FUTURE CONSERVATION STRATEGIES IN THE INDUS BASIN

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Introduction

As we enter the 'Greenhouse' century of climate change with its greater likelihood of extreme droughts and floods, most countries are going from boom to bust. At the end of 20^{th} century, 150 years modern irrigation age is winding down. The cultural, economic and political forces that shaped this era are being realigned. On the economic front, irrigation expansion in many areas has reached the point of diminishing returns. Indus basin is no exception, and is more vulnerable to such global changes (climate and trade) because of its political ecology and narrow resource base. Until recently, the country having1400 M^3 per capita water, was net food importer. Many economists believe that water scarce countries can generate much more income from water by using it in commercial and industrial enterprises and purchase their grain in international market. This tidy logic is shaken by the rapidly growing population, which will be living in water scarce countries, will follow this path. Water long left of the food security equation, may now be driving it. As domestic competition for water spills into international competition for grain, it will be the poor of these food deficit nations that lose out. Without a concomitant rise in the income levels of the very poor, a rise in food prices in the wake of URAoA regimes could place the health and lives of many additional millions at risk. Confronting this threat head-on will take efforts to raise the domestic food production in the country. Thus, irrigation water has to play a key role in meeting this challenge in the Indus basin.

Pakistan will soon become water poor country. In many areas, farmers are pumping groundwater faster than nature is replenishing it, causing a steady drop in watertable. Groundwater over-pumping could now be the single biggest threat to Indus agriculture. Over-tapped rivers are easy to see and the consequences are fairly visible. Groundwater overdraft, though hidden from view, is even more serious problem. This, coupled with global warming, will further exacerbate the issue of water insecurity in Pakistan. The pace of dam building is slowing down because of the resource constraints, environmental concerns and regional conflict. The surface water, though scarce, if managed properly, could only ensure the sustainability of agriculture. Now that water is increasingly scarce, however, raising productivity—getting more service, satisfaction and benefit out of every drop we remove from a river (Indus and other tributaries), lakes, mountain spring, or underground aquifer—is the key to meeting future needs of the country. Thus water productivity—getting more crops per drop seems to be the agricultural frontier for Indus basin in the 21^{st} century. The equity ratio in water distribution between head and middle farm is 5:1 and the efficacy of water is only 27 percent. The over all irrigation efficiency of the system is only 26 percent (conveyance efficiency: 75 percent; delivery efficiency: 60 percent and application efficiency: 75 percent).

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Stocktaking of Water Resources

Role of Water in the Economy

The central issue in any less developed country continues to be broadly defined as economic development. Given the low level of income, literacy and life expectancy, high incidence of poverty, malnourishment, and infant and maternal mortality in these countries, it is simply not possible for the government or any other social group to place a higher priority on the pursuit of any objective other than poverty alleviation, human resource development and generalized economic growth. The pressure that these inescapable needs exert on the natural resource base of the country are further compounded by demographic pressure in the form of a high rate of population growth and a correspondingly rapid increase in the urban population. The focus of policy planning and action must, therefore, be on: i) the achievement of a reasonable rate of economic and demographic change consistent with the objective of human development; ii) the mitigation of the effect of these pressures on the natural resource base; and iii) the strengthening of institutions to harmonize development and environmental objectives.

The most essential elements of the natural resource base of any country are climate, land and water. However, water is the most limiting resource for economic development in the arid environments of the developing countries. The pressure exerted by economic and demographic process on the national resource base is a serious concern. Water is already being used at maximum capacity in most of the developing countries. There is scarcely any excess capacity to meet the growing demand of water for the expansion of: a) irrigation; b) provision of drinking water; c) recharging of groundwater supplies and wetlands; and d) flushing away of municipal and industrial wastes. Therefore, water must be seen in the context of:

- Water for Agriculture;
- Water for People; and
- Water for Nature.

All the three above mentioned users of water contribute significantly in sustained economic growth in the country. The Indus basin provides an opportunity for addressing complex and multiple issues related to the conjunctive use of water (precipitation, surface water and groundwater).

Water and Agricultural Economy

Importance of agriculture sector in the economy of country can be viewed from the factor that it contributes significantly to the gross domestic product of the country (25 percent) and provides job opportunities to the labor force (55 percent). It also accounts for most of the total export earnings of the country (80 percent) (Government of Pakistan, 2001). Within the agriculture sector, irrigation plays a predominant role as it provides 90 percent of the total wheat production of the country and almost 100 percent of cotton, sugarcane, rice, fruits and vegetables mainly within 16 million hectares (mha) of the Indus basin. Also, the irrigated agriculture plays a major role in the industrialization process of the country with the production of cash crops (cotton, sugarcane, citrus, mango) and dairy cattle.

During the 60s and 70s, the country benefited from technological development of the Green Revolution through improvements in self-reliance of agriculture and food products due to significant increases in cropping intensities and crop yields. Later during the 80s, the agricultural water management programs in the country also contributed towards increase in agricultural productivity and productions. In the last 50 years, the productivity was almost doubled mainly due to the Green Revolution and improved agricultural water management. This was very much true for the cereal crops like wheat, rice and maize where yields doubled.

Irrigated area increased from 9 million hectares in 1950 to about 18 million hectares in 2000. This doubling in irrigated area in 50 years is a major factor in increasing agricultural productivity and productions. Coupled with increase in cropping intensity from 60 percent in 1950 to 120 percent in 2000 provided a four-fold increase in production as compared to 1950. This four-fold increase was mainly due to increase in water availability from both surface and groundwater sources. This is a sufficient indicator that water contributed significantly in reaping the benefits of Green Revolution Technologies for enhancing production and productivity of the irrigated agriculture in the country.

- With a population estimated at more than 140 million inhabitants today, which is expected to reach 155 million by the year 2010, the demand for food products is expected to continue to grow. Thus, unless there are significant improvements in agricultural productivity (crop per drop) and total production at least in the same order of magnitude as witnessed during the Green Revolution period, the imbalance between supply and demand of basic agricultural goods is expected to increase in the future. This will threaten the self-reliance goal of the country.
- Problems associated with irrigation system and availability of non-water inputs are the main causes for low productivity of the Indus basin. Although, the benefits of irrigation per unit area are fully recognized under the arid environments, little would grow without irrigation. Yet the irrigation sector has become increasingly the target of criticisms and considered to be main cause for productivity problems in agriculture because of water scarcity, inefficiency, inequity, inefficacy and sustainability issues.
- Presently, total water use for agriculture sector in the Indus basin is around 190 billion m^3, contributing 94 percent of the total water use in the country. Thus, agriculture is the largest user of water in the country.

Water for Industrial Economy and Domestic Use

- Presently, total water use for the domestic and industrial sectors in the country is around 10.25 billion m^3 per annum, which is nearly 5 percent of the total water use in the country.
- Availability of groundwater has contributed significantly for the industrial development in the country because it provides demand based system of water availability to the industrial sector.
- Water is an essential element for human life. Thus, provision of safe water for domestic purposes, including drinking and sanitation uses, helps to provide safe and hygienic living to the population in the urban areas.

Water for Nature

- Presently, total water use for the environmental sector in the country is around 1.5 billion m^3, which is approximately one percent of the total water use in the country.

- Diversion of 130 billion m^3 of water to the Indus basin contributes to recharge the groundwater due to extremely low conveyance efficiency. This in combination with rainfall in the basin has created a huge groundwater resource of around 2000 billion m^3 in the Indus basin, which represents about a depth of freshwater of 12.5 meters over the basin area of 16 million hectares. Thus, the indirect contribution to the groundwater recharge is significant.
- Water is an essential element for wild life. Thus, provision of safe water for environmental purposes, including the wetlands and national parks, helps to provide opportunity for recreation to the country's population and tourism industry.

Surface Water and Extent of Irrigation

Pakistan has the best irrigation system in the world. Indus and its tributaries supply surface water, 93 million acre feet (MAF), at the farm gate through 40,000 mile long canals and 130,000 watercourses. Groundwater in the sweet zones is another important source of irrigation water (53 MAF annually). Of the total cropped area, 82 percent is irrigated, 43 percent is irrigated through canal, 37 percent is in conjunctive use and 17 percent has the share of tubewells. Irrigation water is fugitive input and is subjected to over withdrawals. There is a tendency of excessive irrigation through surface supplies as well as groundwater is over drafted. The overall water conveyance efficiency is 45 percent; 75 percent from canal to outlet; and 60 percent from outlet to farm gate. Thus, about 40 million acre feet water is lost in the system (25 MAF canal to outlet and 15 MAF outlets to farm gate). Annually 35 million acre feet is lost to the sea, especially in summer months during the monsoon season. Canal losses are attributed to deferred operation and maintenance. Farm gate losses are due to unlined watercourses and application inefficiencies. The pace of watercourse improvement is slow (only 36000 watercourses have been improved in the last two decades).

The equity and efficacy of irrigation water at the farm is yet another issue. The tail ender is getting one-third of the water available to head farmer. The efficacy is as low as 27 percent. The consumptive use of water per crop or per matured acre is quite low despite affordable supplies. The system losses and application inefficiencies undermine the consumptive use.

Area Irrigated by Sources

Source	Million Hectares	Percentage
Canal	7.79	43.3
Canal cum Tubewells	6.74	37.4
Tubewells	3.00	16.7
Others	0.47	2.6
Total Area Irrigated	18.00	100

Water availability at the farm gate:		133 MAF
	Surface water	93 MAF
	Groundwater	40 MAF
Total Watercourses (Nos)		130,000
	Improved (Nos)	36,000
Annual Improvement Rate (Nos)		4,000
Water Conveyance Efficiency		
	From canal head to outlet	75%
	From outlet to farm gate	60%
	Overall	45%

Groundwater - Source

Groundwater is mined through public and private tubewells (493,000). Private farmers install most of the tubewells in sweet water zone. Public tubewells were installed in the Salinity Control and Reclamation Program (SCARP) areas to pump out effluent discharge from waterlogged areas. These tubewells were of bigger capacity installed near canals to pump out groundwater to lower watertable. It was often argued that SCARP tubewells, pumped out recharged sweet water from the canals, did not serve much purpose. However, in certain areas, these tubewells were able to lower the watertable reclaiming valuable agriculture land. These SCARP tubewells outlived their utility and the government decided to privatize these tubewells in a phased manner. The size of the tubewells was large, thus, farmers were unable to purchase them. The SCARP transition program could not be implemented in letter and spirit. Farmers often agitated not to close tubewells unless they could install their own small tubewells. The process was delayed due to untimely electricity connections and other attendant problems.

Presently, private tubewell owners are over drafting the aquifer due to which watertable is going down. The case in point is Balochistan where the draw down is severe and of threatening dimension. Some of the people have started migrating from Chaghai area in search of water. Since water scarcity is looming large, per capita water availability is dwindling. It is important to regulate groundwater carefully in order to arrest over mining of the aquifer.

Tubewell Capitalization and Water Markets

In recent decades, Pakistan has witnessed rapid growth in demand for water, particularly in domestic and industrial sectors due to population growth, urbanization, industrialization and rising incomes. This growth in demand has not been matched by an increase in supply. The problem is compounded by pollution of water, which has reduced its suitability for various uses. At the same time, in traditionally water intensive sectors of the economy such as agriculture, costs of irrigation have increased significantly. Under these circumstances, it is more important than ever to use water efficiently. It is also necessary to anticipate and address inter-sectoral conflicts over allocation and use of water. The standard approach so far has been to advocate reform of water pricing across sectors to reflect the scarcity value of water. This advocacy is based on theoretical and empirical evidence on the need and desirability of such reforms including willing-to-pay studies. Nevertheless, major users of water, particularly of irrigation water, have resisted these reforms so far. In this context, economic theory tells us that markets increase economic efficiency by allocating resources to their most valuable uses. In other words, if certain conditions are met, markets provide the correct incentives and lead to efficient resource use. Therefore, one way to change the incentives, so that water users support the reallocation of water and achieve efficient allocation of water, is through water markets. These allow water users to buy and sell water, thus, changing the whole incentive structure and breaking the logjam of water-pricing reforms. When water users can gain from reallocation, they would be willing to sell water or pay a higher price for new supplies.

Table 1: Tubewell development in Pakistan.

Period	Number of Tubewells		
	Electric	Diesel	Total
1970-71	36 921	60 301	97 222
1975-76	60 386	100 569	160 955
1980-81	83 855	115 818	199 673
1985-86	99 224	158 058	257 309
1990-91	113 635	226 205	339 840
1995-96	113 823	369 962	483 785
2000-01	125167	420402	545569

Source: Agricultural Statistics of Pakistan, 2000-01.

Irrigation plays a key role in Pakistan's strategy for increasing agricultural productivity. Surface irrigation has allowed the extension of cultivation into areas and seasons that lack sufficient rainfall for agriculture. However, public and irrigation systems do not provide farmers with adequate water or enough control over irrigation deliveries to meet the demands of the more intensive agriculture that came in the wake of Green Revolution and increasing population pressure in Pakistan. Moreover, allowances are not made for water losses in the channels. Problems with operation and maintenance of the canal systems mean that tail-end distributaries and watercourses do not receive enough canal water for the current cropping intensity, and delivery schedules are unreliable in many areas.

All this has led many farmers towards groundwater from private tubewells as a sole or supplement source of irrigation. However, tubewell ownership is limited to a relatively small proportion of farmers, who tend to be the larger and more affluent landowners. Sale and purchase of groundwater through informal water market offers other farmers the opportunity to use groundwater.

Water markets have been in operation in many countries including Pakistan. Although informal water markets have been in operation since decades, they are gradually developed in Pakistan over the past two decades. The formal markets having well defined, private and transferable water rights are relatively of recent origin. In several cases, water trading has helped to overcome water scarcity and increased farm income. International experience also equally demonstrates that formal and well developed water markets provide incentives for conservation and more efficient use of water. Farmers have responded by switching to water-saving technologies (drip and sprinkle irrigation) and high-value, less water consumptive crops.

Many regions of the world are switching to water markets as best alternative to allocate water among the competing sectors. When the irrigators can buy and sell water at will, they have to use allocated water supply more carefully. For instance, if farmers use water more efficiently, they can increase their incomes by trading the water they save. Farmers can choose to grow less thirsty crops; they are at liberty to sell the water they no longer require. The recent experience with informal water markets in Pakistan has been encouraging, although there have been only limited gains as markets have remained informal, site-specific and traditional at best due to supply oriented and ridged water distribution system. Formal water markets can only work where the farmers have legal rights to their water and where these rights can be traded. Formal water markets can provide cost effective alternatives to augment water supplies rather quickly.

Water markets provide one of the most promising institutional mechanisms for increasing access to irrigation from groundwater, particularly for tenants and small farmers. While water markets are found in all provinces of Pakistan, they are most prevalent in canal-irrigated areas of Punjab and North West Frontier Province (NWFP). Large landowners are more likely to own tubewells and pumps, while smaller landowners and tenants are more likely to rely on purchases from other farmers' tubewells for access to groundwater. Contractual arrangements for water include hourly charges, buyer providing the fuel plus a fee for wear and tear, and sharecropping for water.

The recent evidence in Pakistan shows that informal markets are developing over time and canal water is freely traded, often sold and bought. The survey results reveal that 6-7 percent of the sampled farmers buy and sell water at head and 20 percent sell water at the tail end of the distributaries. However, over 80 percent of head and middle farmers trade water. The canal water rate varies from 2-3 dollars per hour mostly to neighboring farmers. Sale of groundwater is quite common, and due to short supplies of surface water, conjunctive use of water is increasing. Almost all the tubewell owners at the head and middle reaches sell water whereas over 50 percent tail enders also sell water. The tubewell water rate varies from $ 1.00 per hour to $ 3.00 per hour. The distance over which water can be transported provides a limitation to water market sales, but lined watercourses increase the distance over which tubewell water can be sold.

Unreliability of access to purchased tubewell water is another problem for water buyers. Purchasers are more likely to have unreliable access to groundwater if they buy water from small-capacity, electric-powered tubewells, or if they are young and own little or no land.

Policy measures to improve access and reliability of groundwater through water markets include increasing the density of tubewells, especially by assisting small farmers to purchase tubewells; lining water delivery channels; and providing more reliable electrical power supply to rural areas. Furthermore, the replication of Participatory Irrigation Management on the Pattern of Hakra 4-R will improve reliability of irrigation water and canal supplies will be increased.

Table 2: Province-wise number of tubewells - 1997-98 (Nos, 000).

Province	Public			Private			Total		
	Electric	Diesel	Total	Electric	Diesel	Total	Electric	Diesel	Total
Punjab	8.9	0.1	9.0	70.7	355.6	426.3	79.5	355.7	435.2
Sindh	4.3	0.1	4.4	13.7	5.5	19.2	18.0	5.6	23.6
NWFP	1.3	0.1	1.4	8.9	1.6	10.5	10.2	1.7	11.9
Balochistan	1.0	0.9	1.9	10.7	9.4	20.1	11.9	10.3	22.2
PAKISTAN	15.5	1.2	16.7	104.0	372.1	476.1	119.6	373.3	492.9

Source: Provincial Agriculture Departments

Of the total surface irrigation water, 110 million acre feet is diverted to canals, 70 percent of the water is withdrawn in Kharif season and 30 percent in the Rabi season. Canal withdrawals have been quite erratic in the past decade depending upon the snowmelt and rainfall during the monsoon. The provincial share in the Kharif withdrawals was 49 percent, 47 percent, and 4 percent, and Rabi withdrawals was 54 percent, 43 percent and 3 percent in Punjab, Sindh, Balochistan and NWFP, respectively, in the year 1998-99. The availability of water as per canal withdrawals is 1.5 acre feet, 5 acre feet, 1.5 acre feet and, one acre feet per cropped acre in Punjab, Sindh, Balochistan, and NWFP, respectively. This shows that surface water is not enough to cater the consumptive needs of crops. Thus, surface supplies are augmented with conjunctive use of tubewell water at very high pump age cost. The surface water at the farm gate in only 93 million acre feet. 17 million acre feet is lost in the canal system, which needs to be conserved through canal lining in brackish water zones and regular repair and maintenance.

Table 3: Province-wise canal withdrawals (million acre feet).

Kharif crops

Year	Punjab	Sindh & Balochistan	NWFP	Total
1989-90	33.95	29.21	2.11	65.27
1990-91	35.90	31.07	2.01	68.98
1991-92	34.85	34.17	2.04	71.06
1992-93	31.28	28.20	2.10	61.58
1993-94	34.90	24.00	2.40	61.30
1994-95	32.60	22.60	2.10	57.30
1995-96	31.10	29.30	2.40	62.80
1996-97	35.10	34.80	2.80	72.70
1997-98	32.80	32.13	2.57	67.50
1998-99	36.41	33.84	2.54	72.79

Table 3: Province-wise canal withdrawals (million acre feet). (Continued)

Rabi crops

Year	Punjab	Sindh & Balochistan	NWFP	Total	Grand Total
1989-90	20.11	15.46	1.25	36.82	102.09
1990-91	22.30	17.18	1.26	40.74	109.72
1991-92	19.45	17.74	----	37.19	109.46
1992-93	21.28	16.56	1.49	39.33	100.91
1993-94	18.80	15.60	1.60	36.00	107.30
1994-95	20.50	15.00	1.60	37.10	94.40
1995-96	21.10	16.70	1.80	39.60	102.40
1996-97	20.00	16.70	1.70	38.40	111.10
1997-98	18.41	15.77	1.46	35.64	103.14
1998-99	20.01	16.39	1.51	37.71	110.07

Source: Water Management Directorate, WAPDA

The recent initiative by the armed forces for canal cleaning (22,000 miles) is laudable and goes a long way in increasing the productivity of crops. The same zealous effort may be replicated for proper maintenance of the rest of the canals. The present system of canal withdrawals is based on political consideration. Distribution of surface supplies must be cropping pattern oriented, and canal withdrawals may be measured and monitored through telemetry. The recent initiative of the distribution of water must be done in close collaboration with provincial agricultural departments and the Ministry of Food, Agriculture and Livestock. Government should consider constituting a canal water distribution and monitoring committee under the auspices of Provincial Irrigation Development Authorities (PIDAs) duly representing the irrigators and respective provincial agricultural departments.

The Escapage Surface Water below Panjnad and Kotri

The Escapage below Panjnad and Kotri is 22 million acre feet and 35 million acre feet annually (3). The average flow below Kotri is as high as 47 million acre feet (Table 4). The outflow is more in the month of July and August depending upon the volume of monsoon rainfall. The down flow below Panjnad goes to Indus, which can be further utilized, but escapage below Kotri (35 MAF) is a cause for concern. Some of the outflow (10 MAF) is essential to check seawater intrusion and preservation of mangroves, and the rest needs to be conserved through construction of upstream dams. The Kala Bagh dam envisaged for this purpose has been subjected to unnecessary political controversy.

Table 4: Escapages below Panjnad and Kotri barrages (MAF).

Year	Panjnad below			Kotri below		
	Kharif	Rabi	Total	Kharif	Rabi	Total
1989-90	10.9	2.3	13.2	16.9	0.4	17.3
1990-91	17.1	4.7	21.8	38.2	4.1	42.3
1991-92	21.9	3.1	25.0	50.1	3.2	53.3
1992-93	30.2	4.2	34.4	69.2	12.3	81.5
1993-94	14.6	0.6	15.2	28.5	0.6	29.1
1994-95	24.2	2.7	26.9	88.2	3.6	91.8
1995-96	32.0	2.6	34.6	61.1	1.7	62.8
1996-97	28.9	1.8	30.7	44.7	0.7	45.4
1997-98	15.46	9.68	25.14	16.98	3.81	20.79
1998-99	15.26	6.68	21.94	32.50	2.15	35.15

Source: Water Management Directorate, WAPDA

The Provincial Canal Withdrawals and Annual Variation

The Indus and its tributaries divert water through 40,000 miles long canals. Some of the canals are perennial and others are non-perennial. The canal system can be safely divided into six zones based on the particular river supplies. The Peshawar valley draws water mainly from Swat and Kabul rivers. Total discharge capacity is 3350 cusecs encompassing a gross command area of 696,000 acres. All canals are perennial and the net irrigated is 606,000 acres depicting average irrigation intensity (*Irrigation Intensity = net irrigated area/gross command area*100*) of 87 percent. Second is the northern zone-Indus plains drawing water from Jhelum, Chenab and Ravi rivers. The capacity of canals from the Jhelum river is 7000 cusecs, gross command area is 2.2 million acres, perennial net irrigation area is 1.6 million acres and non-perennial is 389,000 acres. The irrigation intensity is 93 percent. Total canal capacity from Chenab river is 25,500 cusecs with gross command area (GCA) of 6.9 million acres. The net irrigated area (NIA) through perennial canals is 4.3 million acres and non-perennial is 1.6 million acres. The average irrigation intensity on these canals is 86 percent. Most of the water of Ravi river is lost to India under famous Indus Water Treaty (1960); however downflow streams supply water to center and lower Bari doab canals with total capacity of 14100 cusecs. The GCA is 2.5 million acres, perennial NIA is 2 million acres, and non-perennial NIA is 43000 acres showing acreage irrigation intensity of 83 percent.

Third zone is northern plain drainage water from Sutlej and Punjnad. Most of the canals are non-perennial. Total capacity is 10,100 cusecs. The GCA is 1-6 million acres of which 0.51 million acres is served through perennial source and 6.94 million acres through non-perennial source. The average irrigation intensity of these canals is 89 percent. Fourth zone is northern plain drainage water mainly from the Indus river. The capacity of this is huge (110900 cusecs) with GCA 22 million acres. Of the total GCA, 13.57 million is perennial canals and 5.96 million acres is non-perennial. The irrigation intensity is 88 percent. The southern plain on Indus river includes Pat feeder, desert and Begari Sindh and Ghotki canals with 45,200 cusecs capacity. The GCA is 3.26 million acres. All the canals are non-perennial covering an area of about three million acres and the irrigation intensity is 92 percent. The last and the second largest southern plain, Indus river has a capacity of 181900 cusecs providing irrigation water to 14.46 million acres. The perennial area is 7.29 million acres and non-perennial is 5.6 million acres. The irrigation intensity is 92 percent.

Water Balance in the Indus Basin

The total water is flowed from Indus river and its tributaries is 139 million acre feet annually (Table 5). The total consumptive use is 46 million acre feet (consumptive use: 31 MAF, municipal use 5 MAF and outflow to sea 10 MAF) and the losses are 93 million acre feet. The losses through the surface supplies are huge. Water losses are of two types, conveyance losses (68 MAF) and loss to the sea (25 MAF after accounting for seawater intrusion). The conveyance losses include canal to watercourse head (26 MAF) losses for watercourse head to outlet (35 MAF) and application losses (12 MAF).

Table 5: Water balance for Indus basin (2001-2002)

A. Water Inflows (+/-)

Sr. No.	Water Inflows	MAF	% Share
1.	Rim Station Inflows	139.00	93.10
2.	East River's Contribution	2.00	1.34
3.	Tributary Inflows	8.30	5.56
4.	Storage Changes (+ / -)		
	Total Water Inflows		

B. Water Uses (-)

Sr. No.	Water Inflows	MAF	% Share
1.	Canal withdrawals		
	Head of Watercourse	78	
	Field Nakas	43	
	Consumptive Use	31	29.81
	Conveyance Losses (Canal)	26	25.00
	Conveyance Loses Head to Naka	35	33.65
	Field Application Losses	12	11.54
	Total Canal Withdrawal		
	(Consumptive Use + Losses)	104	100
2.	Industrial and Municipal Uses	5	3.5% of A-1
3.	Required See Outflow to Check Sea Intrusion	10	
	Total Use of Water	46	
C	Water Losses		
1.	Conv. evap. and other losses	68	
2.	Excess Outflow towards Sea	25	
	Total Water Losses	93	

Surface Water Balance (MAF)

Inflows	=	Uses + Losses
A	=	B + C
139	=	46 + 93

Other Water Sources

Groundwater	MAF	% Share
SCARP	9	17
Private	44	83
Total	53	100.00
At Field Nakas	41.00	
Crop Consumptive Uses	29.00	
Field Application Losses	24.00	

Groundwater Balance (MAF)

Total Ext. = Consumptive Use + Losses

53 = 29 + 24 MAF

Rain 30

Consumptive Use 9

Run Off 17

Field Application Losses 4

Rain Water Balance

Total Rainfall = Consumptive Uses + Losses

30 = 9+21

Overall Water Balance

Surface.Flows + T-Well + = 139+53+30

D = 222 MAF

Consumptive Use + Losses + Outflow = 84+113+25

E = 222

Besides surface water, the country is endowed with groundwater resources. The groundwater is pumped through SCARP tubewells (9 MAF) and private tubewells (44 MAF). Of the total groundwater (53 MAF), 29 million is consumptively used for crops and the rest are losses. Public tubewells were installed in late 50s and early 60s to control waterlogging and salinity. The design capacity of these public tubewells was 4-6 cusecs and they were installed in the periphery of canals. Through these tubewells, effluent water was pumped and discharged in the canals. The scarp tubewells outlived their utility and phased out. Since the capacity of these tubewells was large, farmers were unable to purchase and maintain them. It was deemed appropriate to let these tubewells die their own death till private sector install led their own tubewells.

Private tubewells are a big source to augment surface supplies and consumptive use of water. These tubewells are energized through electricity and diesel. The electric tubewells have been running on flat rate basis, which has caused over-exhaustion of the aquifer. This calls for a preventive regulation in order to preserve and manage groundwater efficiently. Until recently, the government has switched to meter-system and electricity tariff is high, therefore, farmers are unable to bear high cost of water through electric pumps. In Balochistan, flat rate is continued in spite of the evidence of over-exhaustion of the aquifer. The watertable of Quetta valley has a severe draw down. Due to drought, most of the wells have been dried up. It is, therefore, necessary to invoke rural regulation for groundwater development and its proper management.

In addition to above two sources of water, rainwater, especially in monsoon, is available. Annually about 30 million acre feet of water is received, of which, 9 million acre feet is consumptively used and rest are losses through seepage, run-off and outflow to sea. Rainfall is a natural gift and the country has to manage and conserve rainfall water, especially in Rodkohi areas where large tracks of land can be brought under cultivation by proper diversion.

Overall water available is 222 million acre feet (surface flows; 139 MAF + tubewells, 53 MAF + rains; 30 MAF). Out of this total water availability, 84 million acre feet is consumptively used, 113 million acre feet are losses and 25 MAF outflows to the sea. This shows overall water balance of the Indus basin.

Water Issues in the Indus Basin

- shortage of water - vis-à-vis water storage
- seasonality in water availability and inflexible canal irrigation system
- inequity in water distribution
- inadequate O&M funding and poor cost recovery
- increase in waterlogging and salinity hazards due to poor maintenance
- excessive groundwater pumpage in certain regions resulting in secondary salinization
- effluent disposal and related environmental issues
- absence of conducive environment required to introduce and implement water efficient irrigation techniques and practices
- lack of private sector participation
- deteriorating institutional capacity of key water sector institution
- poor linkages among water, agriculture and rural development policy strategies
- lax water shed management silting existing water reservoirs
- lack of consensus on dams sites leading to hydro-politics

Future Options for Water Development

Pakistan has a tremendous potential for additional storage to replace lost capacity of existing dams, which is to the tune of 6 million acre feet. In addition, there are 18 feasible dam sites where additional storage can be built. Out of these 18 sites, Kala Bagh, Basha, and Akhori Sakurdu are the best conceivable sites. The feasibilities of Kala Bagh (6.1 MAF) and Basha (7.3 MAF) are near completion in the years 2004 and 2006, respectively. There is a need to develop national consensus in order to conserve 13.4 million acre feet of water. If the nation would not decide upon such important projects of water, the country would experience water shortage. Thar, Cholistan and vast land in Balochistan have already faced a brunt of it. There is a need to conserve 35 million acre feet of water, presently out-flowing to the sea.

As pointed out earlier, there are colossal losses through conveyance and canal watercourses. Therefore, lining of canals, raised section and watercourse improvement will save another 20 million acre feet of water. The pace of watercourse improvement is very slow and in the past three decades, the country was able to improve only 30,000 watercourses from a total 130,000 watercourses. This is not a happy augury and the government may divert resources for watercourse improvement as a crash program to conserve water. Maintenance of canals and their cleaning remained a major issue and mostly canal maintenance has been deferred due to scarcity of resources.

The current allocation of the required operation and maintenance (O&M) cost is 87 percent, 76 percent, 41 percent and 53 percent in Punjab, Sindh, NWFP and Baluchistan, respectively. The actual releases against these allocation are even less. The recovery of O&M cost is 32 percent, 22 percent, 38 percent and 12 percent in Punjab, Sindh, NWFP and Baluchistan, respectively. Last year, the present regime followed a holistic approach to clean canals on a war footing and out of 40,000 miles canals, 50 percent have already been cleaned with the help of Army and local people. This has greatly helped in achieving equity between head and tail end farmers. This has saved water up to 15 percent, which has been translated in the wheat productivity as a result of bumper crop this year.

There is a large area of Rodkohi, Salaba and Riverine areas covering about 3.25 million hectares. This can be brought under cultivation through spat irrigation system, proper diversion and sinking of tubewells in Salaba and Riverine areas. The construction of check and delay action dams in Balochistan area will help address the water scarcity issue. In the rain fed areas, small dams and earthen ponds can be constructed to store run-off water in mountains. In NWFP, Punjab and Balochistan, two million acre feet of water can be made available through such small irrigation schemes and dams.

Groundwater with existing contribution of 53 million acre feet is becoming a parallel source of irrigation but its rising cost may automatically be served as a regulatory mechanism to pump less water ranging between 10-15 million acre feet. In the wake of water scarcity and drought, the country must conserve its groundwater resources for future years. The fugitive supply of groundwater will over exhaust the aquifer. Water managers must endeavor to utilize water resources efficiently. The country can save up to 55 million acre feet water through energy and efficient pumping system. There is a need to increase cropping intensity within Riverine areas by proper water management at the system level.

Options for Future Water Development

Options

- conserve flow of water
- water allocation based on marginal productivity
- experience water shortage in the new millennium

The future strategies to be followed are listed below:

Surface Water

- additional storage to replace lost capacity of existing dams - 6 MAF
- additional storage to add new supplies to the Indus basin canal diversions - 14 MAF
- saving of conveyance losses in canals and watercourses - 20 MAF
- development of Spat Irrigation System in Rodkohi, Salaba and Riverine areas covering 3.25 million hectares
- small dams and earthen ponds to store runoff in mountainous and barani areas of NWFP, Punjab and Baluchistan - 2 MAF

Groundwater

- existing contribution of groundwater - 40 MAF
- reduction in groundwater pumping due to high energy prices - 10 MAF
- sustained pumping up to 55 MAF through energy efficient pumping systems

Future Strategies

- crash Program for cleaning and lining of raised section of canals, watercourses, minors and distributaries
- remodeling of outlets for uniform distribution of water
- crop independent water rates (Abiana) may be charged on gross farm area in order to recover the O&M cost and gradually moving to a volume based pricing
- Minimize element of rent seeking by irrigation personnel
- participatory water management through Provincial Irrigation Development Authorities (PIDAs) may be encouraged at secondary and tertiary canal level
- investment in surface supplies to improve remaining 74,000 watercourses. (The current pace is slow)
- groundwater pumpage may be regulated through licenses in order to check over draft of the aquifer
- consensus on new dam sites is imperative to ensure water supplies
- improve water-shed management to halt silting of dams (Tarbela and Mangla)
- increase cropping intensity within Riverine area by better water management at system level

The options for improving irrigation water productivity are:

- technical (land leveling, surge irrigation, high irrigation efficiency technologies (HIET)—drip and sprinkler)
- managerial (better scheduling, improve canal operations, water application at critical period, water conservation tillage, better O&M and drainage reuse)
- institutional (establishing of water users associations (WUAs) for managing the system, reduction of water subsidies and introducing conservation-oriented pricing, water markets, private sector initiative for developing HIET)
- agronomic (selection of crop varieties with high yield per liter of transpired water, inter-cropping, better matching and sequencing crops, drought tolerant crops and evolution of water-efficient crop varieties)