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Valuation and Pricing of Surface Water Supplies in Pakistan

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1. INTRODUCTION

Pakistan has the largest contiguous, well-articulated, and comprehensive irrigation system in the world, with 3 storage reservoirs, 68 small dams, 19 diversion barrages, and 45 canal commands with 12 Link Canals for inter-basin transfer of water. About 0.1 million outlets supply water to the farmers to irrigate land besides more than 600,000 tubewells. The whole irrigation network commands an area of 45 million acres (18.22 Mha) out of which 79 percent is irrigated by canals or tubewells/wells. More than half of the canal irrigated areas (58 percent) is irrigated perennially and 42 percent non-perennially [NWSR (2002)].

The average annual flow of Indus River System is approximately 151.58 million acre feet (MAF) of which presently 103.81 MAF (128.1 BCM) is being diverted to irrigate farm lands [NWSR (2002)]. The present live storage capacity of the reservoirs is about 12.5 MAF (13 percent of river flows) compared with the original capacity of 15.7 MAF. The hydropower generation is constrained by seasonal inflows to reservoirs and irrigation requirements by Indus River System Authority. The generation dictated by irrigation requirements is the highest in the months of July to October. Little more than half of the diverted flows (55 percent) become available at farm gate, 42 percent infiltrate to groundwater reservoir and balance 3 percent is lost as evaporation. Of the total water that seeps down to the groundwater reservoir, including some 27 percent of farm gate supply through field seepage, nearly 85 percent is being extracted. Groundwater owing its existence to operational canal system, supplies over 40 percent of crop water requirements of the country.

Water is essential for living beings constituting 50 to 90 percent of the weight of living organisms. Presently water available in Pakistan is 1050 m^3/capita/annum, very close to the 'water stress level'. On an average it takes roughly 70 times more water to grow food than people use directly for domestic purposes [SIWI and IWMI (2004)]. In view of high demand for crop production, the stress is with reference to the availability for irrigation purposes and not for domestic/hygienic/industrial use leaving aside its quality. Irrigation to crops use about 93 percent of the water currently utilised in the country. The rest is used by urban and rural population/industry. Driven by increasing population, rapid urbanisation and industrialisation, there is an ever growing demand and pressure on water resources and it is likely to increase dramatically in years to come. The future demand for the year 2010-11 and 2024-25 has been estimated as follows:

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Table 1

Irrigation Water Requirements

S. No.	Requirement/Availability	2000-01 (MAF)	2000-01 (BCM)	2010-11 (MAF)	2010-11 (BCM)	2024-25 (MAF)	2024-25 (BCM)
1	Net Irrigation Water Requirement	77.31	95.32	88.94	109.65	92.08	113.52
2	Non-irrigation Requirement	5.09	6.27	8.93	11.01	15.32	18.87
2.1	Urban Water Supply	3.10	3.82	5.10	6.90	10.24	12.60
2.2	Rural Water Supply	0.81	1.00	1.86	2.30	3.24	4.00
2.3	Industrial Use	1.18	1.45	1.47	1.81	1.84	2.27
3	Return Flows to River	–1.44	–1.78	–1.90	–2.34	–7.53	–9.29
4	Total net Water Requirement	80.93	99.82	95.97	118.35	99.85	123.12
5	Groundwater Availability	30.75	37.91	31.25	38.53	31.75	39.14
6	Net Surface Irrigation Requirements	50.18	61.91	64.72	79.82	68.10	83.98
7	Canal Head Requirement	116.42	143.53	135.74	167.35	134.07	165.28
8	Mean Annual Surface Water Available						
8.1	With Additional Storage Scenario	103.81	128.00	103.81	128.00	121.81	150.30
8.2	No Additional Storage Scenario	103.81	128.00	103.81	128.00	103.81	128.00
9	Shortfall						
9.1	with Additional Storage Scenario	12.61	15.53	31.93	39.35	12.26	14.98
9.2	with No Additional Storage	12.61	15.53	31.93	39.35	30.26	37.28

Source: Pakistan Water Sector Strategy (2002).

Given the backdrop of emerging water scenario, the paper focuses on water valuation for irrigation purposes and pricing aspects starting with an overview of the water resource base. It is followed by present system of water pricing (*Abiana*) and determining the value of surface irrigation water using indirect approaches. The last Section concludes with the proposed water pricing system with reference to increase in produce prices aimed at its economical use and proper upkeep of the irrigation system. The calculations where made are with reference to the figures for Punjab province.

2. WATER RESOURCES

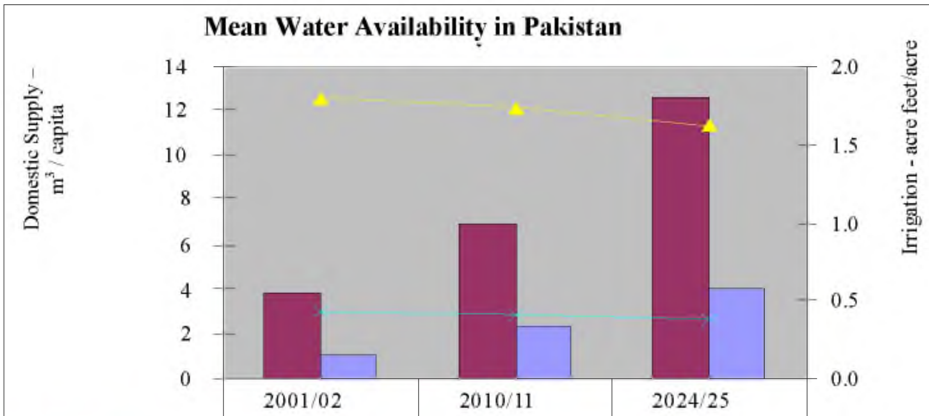
Water is not a static resource like land but occurs in a very dynamic cycle of rain, runoff and evaporation, with enormous temporal and spatial variations as well as variations in quality that govern its value to people and ecosystems [Rijsberman (2005)]. Surface water is by snowmelt of the northern glaciers that feed the Indus River system. For the period from FY1976 to FY2004, the average annual total flow of all rivers in the Indus system was 183.46 BCM, most of which (81.79 percent) is in the *kharif* (summer) season and remaining (about 18 percent) in the *rabi* (winter) season (PER, 2007). The aggregate annual average flows in the three western rivers controlled by Pakistan (Indus, Jhelum and Chenab) is 173.38 BCM, of which 142.5 BCM occurred during *kharif* and about 30.89 BCM (25.05 MAF) in *rabi* season. An important feature of river flows is however, their variability attributed global warming, necessitating the need for additional storages.

The Indus plain is underlain with rich alluvial deposits more than 1,000 feet deep. Most rainfall occurs in the monsoon season beginning from July. January and February have sporadic winter rainfall that sometimes extends into March. Spatial rainfall patterns are highly variable. Rainfall intensity is highest in the northern mountains Due to continuous lowering of the groundwater level in the aquifer caused by unregulated extraction water tables are falling below the natural surface level. Shortage of canal water during droughts in the Indus command tends to exacerbate the problem of groundwater overdraft[1]. The introduction of subsidy on electric tubewells has resulted in lowering of water table all over the Indus plain but drastically in Pishin-Lora, Nari and Zhob river basins of Balochistan.

3. FUTURE WATER AVAILABILITIES

Total surface water availability of the system is 128 BCM out of which 11.01 BCM is the non irrigation requirement for 2010-11 likely to increase to 18.87 BCM by 2024-25 due to rapid urbanisation and better sense of hygienic conditions. The domestic water supply as well as the industrial requirement is the priority sub sector. The balance surface water availability for irrigation purposes will thus, decrease to 117 BCM by 2010-11 and further decrease to 109.13 BCM by 2025. In view of accelerated exploitation of groundwater to meet crop water needs there is little scope of increasing groundwater production.

Fig. 1.



	2001/02	2010/11	2024/25
Urban	3.82	6.9	12.6
Rural	1.0	2.3	4.0
Kharif	1.794	1.724	1.608
Rabi	0.420	0.404	0.376

Assuming that total irrigated area is 18.21 Mha (45 million acres) and the seasonal variation of flows for kharif and rabi season is 81.79 percent and 18.21 percent, per acre surface water availability is likely to decrease to 1.608 acre feet by 2025 during kharif against 1.794 acre feet in the year 2001. For rabi season, the surface water availability will be 0.404 acre feet in 2010 and further reduce to 0.376 acre feet by 2025. The reduction in 2010 and 2025 will thus, be of the order of 3.9 percent in 2010 over 2001 level and 10.4 percent by 2025.

[1]The farmer is to pay only Rs 4000 per month for an electric tubewell irrespective of the electricity consumption.

Table 2

Mean Surface Water Availabilities in Pakistan

S. No	Description	2001-02	2010-11	2024-25
1	Total Surface Water Availability – BCM	128.00	128.00	128.00
2	Industrial Use – BCM	1.45	1.81	2.27
3	Urban Water Supply – BCM	3.82	6.9	12.6
4	Rural Water Supply – BCM	1.0	2.3	4.0
5	Urban Population – Million	48.6	71.8	114.5
6	Rural Population – Million	92.4	101.5	106.5
7	Per Capita Supplies in Urban Areas – m^3 (3/5)	78.6	96.1	110.0
8	Per Capita Supplies in Rural Areas – m^3 (4/6)	10.8	22.7	37.6
9	Net Surface Water Availability – BCM	121.73	116.99	109.13
	= MAF	98.69	94.84	88.47
10	Per Acre Surface Water Availability during Kharif – Acre Feet	1.794	1.724	1.608
11	Per Acre Surface Water Availability during Rabi – Acre Feet	0.420	0.404	0.376

- Per acre water availability for surface irrigation will decrease by 3.9 percent in 2010-11 and 10.4 percent by 2025 compared with 2001 level.
- Non Irrigation water uses will increase by 75 percent in 2010 and would double by 2025.

4. AGRICULTURE-WATER-ENERGY NEXUS

The productivity of water is low attributed to high water losses, inefficient water application methods, low water availability at critical crop growth stage, sub-optimal mix of crops, poor economic allocation of water etc. High application losses are primarily attributed to negligible water cost of surface water (*Abiana*), subsidised power tariff of electric tubewells, lack of awareness on the part of farmers etc. Planting of high delta sugarcane in most parts of Punjab, 'Pancho' system of irrigating rice fields, nominal charges of Rs 4,000 per annum for electric tubewell are the glaring examples of wasteful use of scarce water. The electric operated tubewells use pumped water in a much wasteful way. The diesel operated tubewell farmers on the other hand pump water using high cost fuel and make its much efficient use. The impact of subsidised electric power at the Water-Energy Nexus are in the form of indiscriminate use of low cost water pumped by heavily subsidised electric tubewells and its optimal use by diesel tubewell farmers [Ahmad and Ahmad (2007)].

5. THE ISSUES

In spite of massive investment in earlier years of Pakistan, water scarcity and inefficient use of water remain the major constraints. It is on account of poorly managed irrigation system, non realisation of the value of water by agriculture as well as from non-agricultural sectors, addition of polluted industrial waste/water in the irrigation system, rapid increase in population etc. The major issues, in addition to decreasing storage due to sedimentation, relating to inefficient water use in agriculture include:, poor maintenance of channels, unreliable irrigation supplies, water shortages at critical crop demand periods, high water pumpage, low *Abiana* recoveries, increased sodicity etc. A critical analysis of the issues boils down to the fact that the system is not properly maintained due to paucity of funds and water is not judiciously used because of its negligible cost. The impact of proper price can be viewed from the glaring example of bottled water which never is wasted or even used for sub-optimal purposes but only for drinking purposes. On the same analogy and water use pattern of diesel tubewell farmer vs. the electric operated farmer, a realistic price would not only discourage its wasteful use but would also result in its near optimal productivity and preserve this natural resource for next generations.

6. HISTORICAL PERSPECTIVE OF *ABIANA*

The history of *Abiana* is centuries old. Initially in kind, but in 1854 a monetised system was introduced for some crops. Feroz Shah Tughlaq (Western Jamna Canal in 1351-88 AD) and Emperor Shah Jehan (Hansli Canal in 1633 AD) introduced recovery of *Abiana* on the basis of Islamic Shariat. The Sikhs (1763-1849 AD) *introduced a system of fixed share of produce varying from one-tenth to one-fifth of crop produce* which could easily be divided. For crops like sugarcane, cotton or tobacco which could not conveniently be divided, fixed rates were charged in monetary terms. The British introduced 'Occupier Rates'[2] for different crops strictly based on productivity. However, to facilitate colonisation and bring the new areas under cultivation the rates were pitched low. As a matter of policy it was decided in 1959 that no increase in water rates should be made for food crops (wheat, maize, gram, pulses) and fodder crops. Instead the burden of these crops was decided to be shifted to cash crops like cotton, sugarcane, tobacco and oilseeds. The policy of fixing *Abiana* rates remained almost steady except that in certain years these are increased across the board but maintaining the old parity amongst the crops. Crop based system is still in practice except in the province of Punjab where flat rate system is introduced since kharif 2003. The criteria adopted in 1959 to form the basis for determining water rate were:

- Interest on capital cost of a canal and its working expenses,
- Amount of water required for the maturity of a crop,
- Water supplied in kharif and rabi season,
- Value of crop produce,
- Government policy towards incentive/disincentive of a crop etc.

The historical trend indicates that initially the *Abiana* rates were in the range of 10-20 percent of the value of a crop. Another study conducted under the ADB TA Grant Project concluded that the cost of irrigation under the diesel-operated tubewells in the province of Balochistan is around 27 percent of the total cost of production of crops or 15 percent of the gross income per ha, which is same as the average rate of *Abiana* levied by the Sikhs in India [Ahmad and Ahmad (2007)]. The huge difference in share of water cost from diesel tubewell compared with surface supplies can be viewed from the findings of this study. It concluded that prevailing water rate for canal supplies as percent of gross revenue varied from a minimum of 0.63 percent for vegetables to a

[2]"The rates to be charged for canal water supplied for purposes of irrigation to the occupiers of land shall be determined by the rules to be made by the Provincial Government and such occupiers as accept the water shall pay for it accordingly. A rate to be charged shall be called Occupier Rate".

maximum of 1.81 percent for rice. In terms of *Abiana* share in overall crop production cost (excluding land rent and family labour) it is only 2.2 percent for vegetables and highest at 4.5 percent for rice [Asif (2007)].

7. WATER RATES RECOVERY IN OTHER COUNTRIES

In most countries, water rate recovery is based on: (a) O&M cost; (b) interest on capital along with O&M cost; and (c) capital recovery in instalments along with O&M cost. The system of water rates prevailing in some of the countries is summarised as under:

- In India the interest on capital cost and O&M cost is recovered.
- In Turkey capital cost is recovered in full over a period ranging from 16 to 100 years in various projects. However, O&M cost is payable in the following year.
- In Egypt, Norway and Thailand no charge is levied.
- In Australia, New Zealand, France, Argentina, Portugal, parts of Nigeria (North Eastern), South Africa and Zambia, only O&M charges are recovered.
- In Iraq, Malaysia, Malawai, Mexico and Philippines, the beneficiaries have to pay their share of capital cost and O&M costs.
- In Chile, the irrigators pay back the full cost in 30 years.
- In Peru, the irrigators pay all costs for new works. In addition they share 1/3rd of the costs for improvement of old works.
- In USA the capital cost is recovered over a period of 50 years in addition to the yearly payment of O&M costs.

The above analysis reveals that some countries are recovering both the capital and O&M cost, while the others are recovering 100 percent of the O&M cost, whereas few countries are not charging at all. Higher water charges, would lead to greater water-use efficiency up to certain extent [Khan (2007)]. Similar views are expressed in the paper by Chaudhry, *et al.* (1993). Higher water-use efficiency will lead to increased cropped area and high water rate under a crop based assessment system which is to the disadvantage of small farmers. However, under the flat rate system, it will lead to higher cropping intensity and increased production across the board.

8. RECOVERY OF *ABIANA*

In order to meet O&M costs, *Abiana* is recovered based on a system of varying water charges according to the crop type. It however, does not reflect the relative consumptive requirements nor takes into consideration the inequitable water supplies in various reaches of the system or reflects the cost of maintaining the system. Flat rate system of assessment has been introduced in Punjab since kharif 2003. The recovery of expenditure in NWFP as reported in Pakistan Water Sector Strategy was 38 percent in NWFP, 32 percent in Punjab, 22 percent in Sindh and only 12 percent in Balochistan [PWSS (2002)]. Similar conclusions are derived by another study carried out under the TA Grant for Balochistan province [Khan (2007)].

Abiana is assessed by Irrigation Department is collected by Revenue Department and deposited in treasury. The collection as a proportion of assessment was better in Seventies but has slowly decreased. The amount assessed as *Abiana* is roughly half of the O&M expenditure. While the assessment increased year after year, the collection dropped significantly from year 2000-01 onwards. The recovery in Punjab as a percentage of assessment decreased to 42 percent in 2004-05 compared to 79 percent in FY 1993-4 and 1994-5. The average collection is 51 percent of demand for the period 2001 to 2006. The recovery for Balochistan canal commands is however, abysmally low at 16 percent during this period.

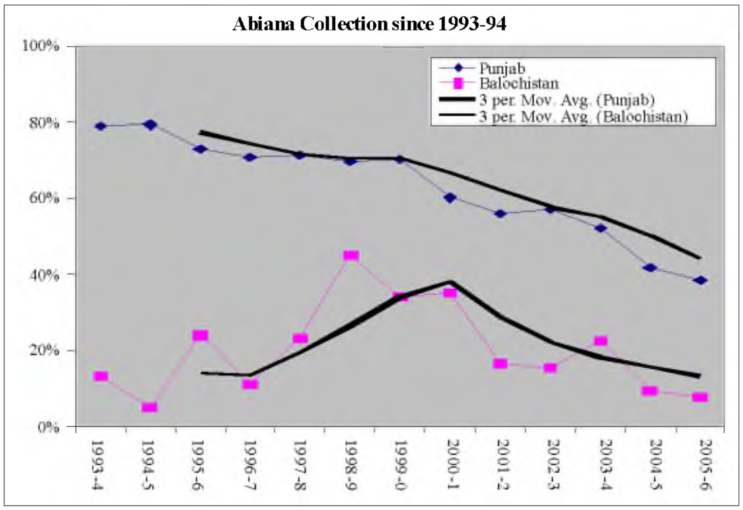


Table 3

Abiana Collection against Current Demand

Year	Punjab Province			Balochistan		
	Demand Mil. Rs	Collection – Mil. Rs	% Recovery	Demand – Mil. Rs	Collection – Mil. Rs	% Recovery
1993-94	812	643	79%	16.04	2.14	13%
1994-95	964	765	79%	15.30	0.78	5%
1995-96	1,091	798	73%	22.75	5.46	24%
1996-97	1,344	949	71%	29.65	3.32	11%
1997-98	1,528	1,088	71%	33.83	7.85	23%
1998-99	1,793	1,252	70%	38.30	17.23	45%
1999-00	2,260	1,346	70%	41.29	14.14	34%
2000-01	2,260	1,357	60%	45.60	16.07	35%
2001-02	2,155	1,211	56%	55.62	9.20	17%
2002-03	2,047	1,167	57%	59.97	9.31	16%
2003-04	2,306	1,205	52%	72.70	16.39	23%
2004-05	2,644	1,108	42%	88.82	8.38	9%
2005-06	2,353	905	38%	110.2	8.60	8%
Avg. 2000-01 to 2005-06			51%			16%

Source: IDP Punjab and Revenue Offices Balochistan.

9. WATER AS AN ECONOMIC GOOD

Abiana collection was sufficient in early Seventies not only to cover the O&M but progressively to recover the capital investment. The rates were kept low as an incentive or disincentive to the growing of a crop or to encourage colonisation. It never reflected the true price of water, which is the difference in crop output value in 'With' and 'Without' scenarios. The value of surface irrigation can however, be gauged by the fact that average market price of irrigated land is many folds higher than the similar un-irrigated land in its neighborhood attributed to the productivity difference made possible by the use of surface water. The returns from irrigated land were calculated as Rs 10,478 per acre of irrigated land vs. Rs 2,476 of the neighboring rain-fed cropping in Pat feeder Command of Balochistan or a ratio of 4:1 [Khan (2007)].

10. *ABIANA* TREND IN TERMS OF PRODUCE SHARE

Theoretically there is strong relationship between *Abiana* rate and produce price, both impacted by inflation. However, a critical analysis of water rate and produce prices shows that the ratio between this important input (water) and the crop output is widening quite apart. Due to ageing of the irrigation system, O&M cost is increasing progressively. The *Abiana* rates are however, not commensurate with the increase in produce income in monetary terms. There is thus, a strong case for gradually restoring the old balance as it existed in early periods of colonisation or at least the level of early Seventies.

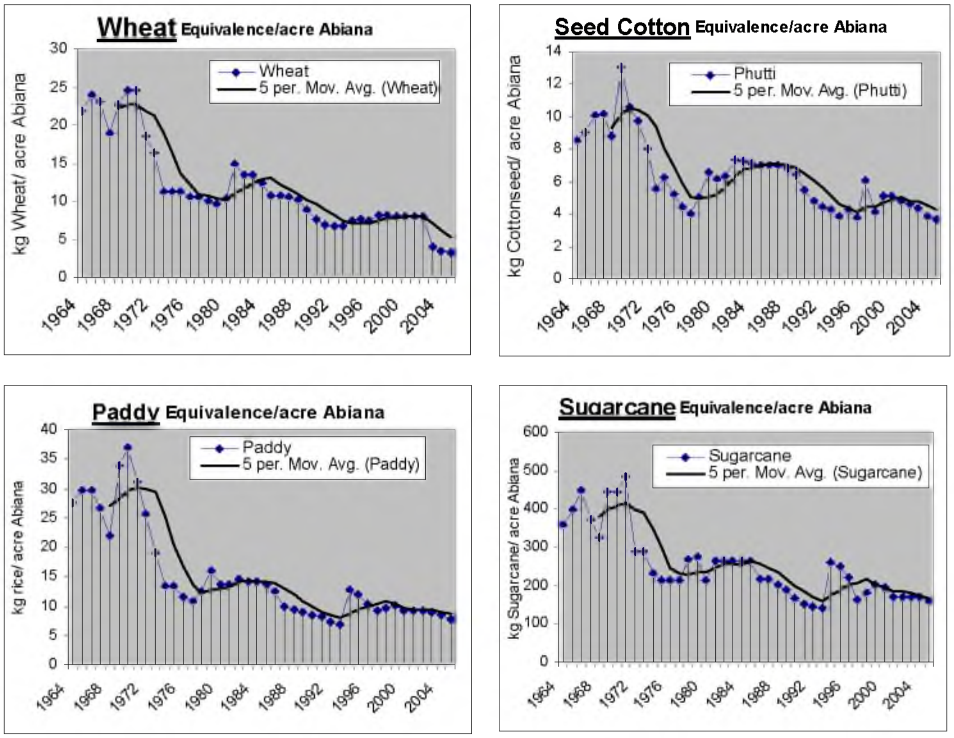
Wheat, rice, sugarcane and cotton utilise roughly 77 percent of total water supplied to the farmers in Punjab. A perusal of *Abiana* rates and the produce price detailed in Annex Table shows that in 1970 one acre *Abiana* of respective crop could haggle for 24.5 kg wheat, 36.9 kg basmati paddy, 10.6 kg cottonseed and 445 kg of sugarcane. With passage of time the produce equivalence *Abiana* decreased to about half by 1985 compared with 1970 level and further decreased drastically by 2005 to just 14 percent for wheat (3.3 kg), 21 percent for basmati Paddy (7.9 kg), 34 percent cottonseed (3.6 kg) and 65 percent sugarcane (157 kg). The down ward trend is visible in the Figure given below also displaying the five yearly average.

Table 4

Produce Equivalence per Acre Abiana–Kg

Year	Wheat	Paddy	Cottonseed	Sugarcane
1965	23.9	29.6	9.0	398
1970	*24.5*	*36.9*	*10.6*	*445*
1975	11.2	13.4	5.2	213
1980	10.4	13.7	6.2	212
1985	10.8	13.8	7.0	265
1990	7.7	8.5	5.5	168
1995	7.6	12.0	4.3	248
2000	8.0	9.2	5.1	197
2005	*3.3*	*7.9*	*3.6*	*157*

Produce Equivalence/Acre *Abiana* in Different Years



- In terms of produce equivalence, the *Abiana* of one acre of wheat could buy 24.59 kg of wheat in 1970 against only 3.3 kg in 2005. For basmati paddy, it has decreased from 36.9 kg in 1970 to 7.9 kg in 2005.
- One acre water rate of cotton was worth 9 kg cotton (phutti) in 1970 that has now decreased to 3.6 kg. For sugarcane, it was worth 398 kg of sugarcane in 1970 against 157 kg in 2005.

11. AUGMENTING WATER SUPPLIES

In order to reduce water cost for surface supplies, efforts need to be made to mitigate the effects of water scarcities on a consistent basis. The possible modes for augmenting water supplies for increased water demand for agriculture/domestic/industrial uses in future include: reduced water conveyance losses, improved irrigation efficiencies, re-use and recycling of saline groundwater, realistic water pricing, rain water harvesting, storing saline water in evaporation ponds and its use after accumulation of salts, judicious water application etc. Wastage can partially be reduced by introducing water metering for domestic water supply and following the principle of "polluter pays" for industrial users etc.

12. VALUE OF WATER

The economic value of water is the amount that a rational user is willing to pay for it. It reflects the water user's willingness to forego other consumption and is measured by a demand schedule relating the quantity of water used at each of a series of different prices. The 'value' generally refers to the power to purchase other goods but it also expresses the value of some particular object. It may thus be accordingly called as 'the value in exchange' or the 'value in use'. The things with greater 'value in use' have frequently little or no 'value in exchange'. In the context of irrigation water, it is the value of water for crop production that has much higher 'value in use' but a nominal 'value in exchange'.

Water is not a finite resource but is re-circulated and has high economic value. Globally, roughly 15-35 percent of irrigation withdrawals are estimated to be unsustainable. Unfortunately, however it is not perceived as an economic good and thus, its wasteful use. The major reason of inefficiency in water use is assigning low value and charging extremely low price of water in all sectors including agriculture, domestic or industrial use. Why a farmer should be efficient or why a household be efficient in water use when it has an unrealistically low price assigned to it!

Theoretically there is direct relationship between the quantity of water delivered and chargeable *Abiana* which involves installing meters. This option is however, impracticable due to a number of reasons including poor law and order situation, fluctuating water supplies, no control over water deliveries, possibility of tampering with the meters, cost-ineffectiveness etc. Even in urban areas water meters installed in certain localities were hardly made use of for water billing. The other major related aspect is limited storage/reservoirs whereby water is released when it is not needed or it may not be available in sufficient quantities when it is needed the most.

13. DETERMINING WATER VALUE

Water has several distinctive features which complicate its supply. It is bulky and expensive to transport relative to its value per unit of weight. It has inelastic demand, can't be stored beyond a certain limit and its availability fluctuates in different seasons. Its value on the basis of incremental applications can not be determined as measurement of crop yield that is a function of incremental water applied in uncontrolled and unpredictable environment, is not possible. Various limitations include significantly varying soil type/fertility level, use of chemical fertilisers, environmental changes, agro economic and cultural practices, water stress level, farmer behaviour, economies of scale etc. Therefore, the estimation of value has to be based on some alternative approaches.

Value of water can be determined based on: (i) recovery of a pre-determined cost (capital and O&M) partially or wholly, (ii) income dependent on the basis of benefits derived from irrigation, or (iii) a combination of both: the cost incurred and benefits derived. Cost based method involves developing a total cost curve based on the operating budget and current expansion plans. The total cost curve shows the relationship between water supply and total costs to the utility. The income based method involves deriving the marginal returns which is the change in value of produce excluding other costs. The incremental value based approach can however, not be adopted due to uncontrolled environment for crop production. Value of water was calculated by WAPDA in 2000. It was done based on: (i) the cost of the project, and ii) estimated net returns from crops likely to accrue based on cropping intensity in various canal commands of the system and returns per unit area. The value was derived as Rs 1,877 per acre foot of water for kharif and Rs 3,380 for rabi season or a weighted average of Rs 2,479. The updated value, compounded at 12 percent rate is Rs 5,481 per acre foot at 2007 level.

14. PRICE DETERMINATION

The benefits from use of surface irrigation supplies are much more than the cost of water incurred on water saving projects. The determination of benefits based on past *Abiana*-Produce relationship becomes all the more difficult due to a number of reasons including subsidised supply of inputs, suppression of crop prices (wheat/rice/ cotton/sugarcane) by procurement/zoning, improper produce market, restrictions on export etc. Various alternates that can be taken as a reference point can be: (i) cost of feasible water saving projects comprising of capital and O&M costs, (ii) the cost of groundwater pumpage by electric/diesel tubewells, and (iii) the recovery of O&M costs necessary to maintain the irrigation system. The price of water derived by these options is discussed below.

14.1. Cost of Water Saved

A number of irrigation projects are undertaken by the government aimed at water saving and restoration/rehabilitation of irrigation infrastructure. The Feasibility Study for 'Improvement of Irrigation System (LCC West, Eastern Sadiqia and D.G.Khan Canals)' has recently been carried out in 2007. Using the cost and benefit streams per acre foot of saved water has been calculated in Table 5. The cost is calculated as Rs 3,722 for LCC West and Rs 4,555 for Eastern Sadiqia. It is higher at Rs 5,355 per acre foot of water saved for the non perennial DG Khan canal. The cost at farm head with canal conveyance efficiency of 75 percent works out to Rs 4,962 for LCC West and Rs 6,074 for Eastern Sadiqia canal.

Table 5

Cost of Water Saving— 2007 Price Level

Description	LCC West	Eastern Sadiqia	D.G. Khan
Discharge – Cusecs	3,648	1,951	2,020
Water Savings with 6 percent Savings due to Project – Cusecs	219	117	121
Cost at Completion – Million Rs	2,466	1,614	1,968
Annual Cost at 10 percent Discount Rate (25 Yr Life) – Million Rs	271	178	216
Annual Cost per Cusec of Water Saved – Million Rs	1.24	1.52	1.79
Command Area per Cusec Water – Acres	333	333	333
Annual Cost per Acre at Canal Head-Rs/Cusec	3,722	4,555	5,365
Cost at Farm Head per Acre Foot of Water (75 percent Efficiency)	4,962	6,074	7,154

Groundwater resources are exploited to supplement surface water supplies to meet growing water demand or in areas where there are no surface supplies. This water is costly and comparatively of poor quality. The farmer will apply high cost groundwater only as long as the returns from its application are higher than its cost. The water cost for different modes of groundwater extraction has been estimated by IPD as Rs 1,005 per acre foot of water for Centrifugal pump and Rs 1,290 for diesel tubewell.

14.2. O&M Cost of Water

The price of water includes capital costs and recurring expenditure. The recurring cost includes the operational cost including establishment and maintenance costs. The bare minimum costs that need to be recovered to keep the irrigation system running are the O&M costs. The O&M expenditure of Punjab Irrigation Department excluding administration, research or developmental works is Rs 5.4 billion for FY 2006-07 including Rs 2.31 billion as maintenance cost. It is likely to increase significantly from 2008 onwards [Ahmad (2008)]. Based on O&M cost, canal withdrawals and taking conveyance losses as 25 percent to farm head, the cost per acre foot of water increased from Rs 103 in 1998-99 to Rs 146 in 2005-06 or Rs 300 per CCA acre.

Table 6

O&M Expenditure of Punjab Irrigation Department

Year	Establishment–bn Rs	O&M–bn Rs	Total-bn Rs	Canal With-drawals– MAF	O&M Cost/Acre Foot – Rs		
					Establishment	O&M	Total
1998-99	1721	2653	4374	56.4	40.7	62.7	103.4
1999-00	1902	2579	4481	54.9	46.2	62.7	108.9
2000-01	2003	2261	4264	44.6	59.9	67.6	127.5
2001-02	2275	1618	3893	40.4	75.0	53.4	128.4
2002-03	2619	1235	3854	48.6	71.8	33.9	105.7
2003-04	2865	1818	4683	55.4	69.0	43.8	112.7
2004-05	3222	1846	5068	44.2	97.3	55.7	153.0
2005-06*	3088	2315	5403	49.2	83.7	62.7	146.4

* Canal withdrawals assumed for 2005-06.

The allocations made to Punjab province vide Water Accord of 1991, are 55.94 MAF. With even water distribution over the entire CAA, availability per acre is 2.729 acre foot which translates to 2.047 cusec at farm head (75 percent efficiency). Assuming 300 days of flows, O&M cost per command acre is Rs 300 at farm head or Rs 109.94 per acre foot of water. The flat rate of *Abiana* is fixed as Rs 135 per CCA acre (Rs 85 in kharif + Rs 50 in rabi season). The assessment rate is thus, Rs 49.47 per acre foot of water at canal head or Rs 65.96 at farm head. The assessment if recovered in full will thus meet 45 percent of the O&M cost of the system for the year 2005-06. It may be mentioned that with just 125 percent cropping intensity, the prevailing assessment is only Rs 108 per cropped acre.

Table 7

Abiana Assessment and O&M Cost for PID

1	Share of Punjab Province vide Water Accord – MAF	55.94
2	CCA of all Canals for Punjab – Million Acres	20.5
3	= Acre Feet/CCA Acre at Canal Head – (1/2)	2.729
4	Water Delivery at Farm Head (3*75 percent Efficiency)	2.047
5	O&M Cost per CCA Acre (2007 Level) – Rs	300
6	= O&M Cost/Acre Foot at Canal Head (5/3) – Rs	109.94
7	= O&M Cost/Acre Foot at Farm Head (5/4) – Rs	146.59
8	*Abiana* Rate/CCA Acre - Rs/Annum	135
9	=*Abiana*/Acre Foot at Canal Head (8/3) – Rs	49.47
10	=*Abiana*/Acre Foot at Farm Head (8/4) – Rs	65.96
11	Assessment as percent of O&M Cost (6/9)	45%

The Operational expenditure of Pat Feeder and Khirther canals in Balochistan province was Rs 156.4 million for the FY 2005-06. Total CCA of the two canal systems in the province (Pat Feeder and Khirther) is 0.769 million acres. The cost of providing water was Rs 203 per CCA acre including the O&M expenditure but excluding capital costs. Though the *Abiana* rates are increased frequently, there hardly is any improvement in recovery. The financial burden can however, be reduced by introducing flat rate system of *Abiana* as introduced in Punjab whereby the assessment cost can be saved.

- O&M cost of surface water supplies is Rs 146 per acre foot at farm head or Rs 300 per CCA acre.
- Average water allowance at farm head is 2.047 acre foot/CCA acre.
- *Abiana* recovery if made in full, will meet 45 percent O&M cost of the

15. PRICING WATER

The economic principles underlying water pricing decisions rest on the idea of benefits and costs. Unfortunately the administrative and budgetary system is acting independently and results in low efficiency, inequitable distribution of water and inefficient cost recovery. Treating water as a public good has led to under pricing of water leading to resource misallocation, misuse, shortages, theft etc. Allocation of water for different competing purposes like agriculture, domestic, power, industrial, environmental and other uses has become increasingly difficult. Part of the problem lies in assigning realistic price for various uses to minimise its wasteful use. It may be mentioned that increase in water price does not necessarily improve the use of water because it is impossible to raise the price to its marginal benefit level due to socio-political constraints. Further the farmer is not getting free market price for his produce while prices for fertiliser and pesticide, the two important inputs are increasing at a much faster rate than the increase in produce price. This results in continuously eroding his net income.

The modern approach to pricing recognises the existence of several objectives or criteria, not all of which are mutually consistent. The resources need to be allocated efficiently. For this the cost-reflecting prices must be used to indicate the true economic costs of supplying consumer needs. Second, certain principles relating to fairness and equity must be satisfied, including: (a) the fair allocation of costs among consumers according to the burdens they impose on the system; (b) the ensuring of a reasonable degree of price stability and avoiding large fluctuations in price from year to year; and (c) the provision of a minimum level of service to certain category of consumers who may not be able to afford the full cost.

Crop production largely depends on surface supplies. A nominal service charge is recovered to meet O&M expenditure. Water rate assessed in Punjab meets 45 percent of the O&M cost of the system. It is abysmally low at just 1.3 percent of the cost of water saving, 5.1 percent of the groundwater pumped by diesel tubewell and 6.6 percent of the cost pumped by electric tubewell. The prevailing rate is 1.4 percent of the value of water derived by WAPDA (Rs 5,481/acre foot). It is less than 2 percent of the gross revenues as derived for Balochistan canal command areas. It neither meets the O&M cost nor encourages its economic use.

Table 8

Cost and Assessment per Acre Foot of Water at Farm head

Description	*Abiana*/ Cost – Rs		*Abiana* Assessed as %
	Per Acre Foot	Per m^3	
Abiana Assessed	66	53	–
O&M Cost of PID	147	119	45.0%
Cost of Water Saved (LCC West)	4,962	4,024	1.3%
Cost of Water Pumped by Diesel Tubewell	1,290	1,046	5.1%
Cost of Water Pumped by Centrifugal Pump	1,005	815	6.6%

> Prevailing water rate is equal to 2 percent of the cost of water saving by improvement of irrigation system. It is 5 percent of the cost of diesel tubewell which is a true indicator of the value of water.

16. DETERMINING *ABIANA* RATE

The cost of water differs widely for different modes of water saving / pumpage. Determining the produce value that can be attributed to water alone is not possible in view of uncontrolled and varying agronomic and social factors. The price of water can conveniently be taken as the costs incurred including capital and O&M costs. The recovery of capital cost in full or a fraction of it is a policy decision. However, in view of insignificant contribution of water to crop production costs and to indoctrinate the sense of economising water and its judicious use, the O&M cost assessed as Rs 300 acre at present needs to be recovered.

The assessment of *Abiana* needs to be determined on the basis of crop share and its delta requirement. The four major crops of Punjab province (wheat, rice, sugarcane and cotton) occupy 69 percent of area. The weighted water requirements based on their delta needs is 77 percent of the total water required. Using these basic parameters, the *Abiana* rate can be determined both for flat rate or the crop based system of assessment, as shown below.

(a) Flat Rate Determination

Flat Rate system entails determining a rate on the basis of command area. Once a decision is made of the amount to be recovered, the rate for kharif and rabi season can be worked out. The rate calculated using a 'per acre recovery' figure of Rs 300 per annum as O&M cost is shown in Table 9 which works out to Rs 191 and Rs 109 for kharif and rabi season respectively. It is derived using the following formula:

$$C_s * C_d / W_t * R$$

Where,

C_s = Share of individual crop
C_d = Crop delta of the crop
W_t = Total water requirement of all crops
R = Amount to be recovered per acre.

(b) Crop-based System

The rate for crop based system of assessment as prevailing in NWFP, Sindh and Balochistan can also be determined on the basis of share of each crop in the annual cropping intensity and delta. Assuming that a recovery of Rs 300 per acre of CCA is to be made, the rate for various crops can be calculated on per crop acre basis using the following formula:

$C_d/W_t * R * 100$

Where,

C_d = Crop delta of individual crop
W_t = Total water requirement of all crops
R = Amount to be recovered per acre.

Table 9

Abiana Determination Based on Rs 300 per CCA Acre Recovery

Crop	Crop Share/ Intensity – % (C_s)	Delta Required – cm (C_d)	Water Required-m3 (W_t)	*Abiana*/Acre – Rs Flat Rate	*Abiana*/Acre – Rs Crop Specific
Kharif					
Sugarcane	4.2	180	749	191	795
Rice	11.3	150	1,693		662
Cotton	16.2	62	1,004		274
Other Kharif	14.3	62	889		274
Rabi					
Wheat	37.2	48	1,784	109	212
Other Rabi	16.9	40	674		177
Total	100		6,793	300	

16. CONCLUSION

(a) Raising *Abiana* rates will lead to marginal improvements in water-use efficiency and higher water productivity. Increasing the *Abiana* on the basis of crop based assessment as prevailing in NWFP, Sindh and Balochistan is not in the interest of small farmers who have comparatively higher cropping intensity.

(b) The cost of water saving under various irrigation projects is around Rs 5,000 per acre foot of water in perennial canals but higher for non-perennial canals. The cost of groundwater pumpage in LBDC command by diesel tubewell is Rs 1,290/acre foot and Rs 1,005 for centrifugal pump in LBDC area.

(c) Compared with the diesel operated tubewells, the utilisation rate of electric tubewells is high and irrigation efficiency is low attributed to cheap water extraction due to subsidised power tariff.

(d) The O&M cost per acre foot of water at farm head is Rs 146.6 or Rs 300 per command acre with an average allowance of 2.047 cusec per CCA acre. The prevailing *Abiana* rate of Rs 135 *if recovered in full,* will meet 45 percent of the O&M cost. The *Abiana* assessed is less than 2 percent of the gross revenues from crops.

(e) Prevailing water rate of *Abiana* charged for surface supplies in Punjab province is only 6 percent of the cost of pumping groundwater by diesel tubewell.
(f) The *Abiana* rates across the board have decreased considerably in real terms compared with the rates prevailing in 1970. In terms of produce equivalence, it is only 14 percent for wheat and 35 percent for sugarcane.
(g) The increase in *Abiana* rates needs to be made progressively only to the extent of recovering O&M cost or Rs 300 per command acre considering the socio-political environment.

Annex Table 1

Abiana Rate, Produce Price and Produce Equivalence for Major Crops in Punjab

1965	8.07	11.2	10.4	24.0	13.5	15.2	46.1	2.4	23.91	29.57	9.03	398
1966	8.07	11.2	10.4	24.0	14.0	15.2	41.4	2.1	23.06	29.57	10.05	449
1967	8.07	11.2	10.4	24.0	17.0	16.8	41.1	2.6	18.99	26.70	10.12	371
1968	9.68	11.2	10.4	24.0	17.0	20.6	47.4	3.0	22.78	21.79	8.78	325
1969	10.40	16.0	16	32.8	17.0	18.9	49.1	3.0	24.47	33.80	13.02	445
1970	10.40	16.0	16	32.8	17.0	17.3	60.3	3.0	24.47	36.95	10.62	445
1971	10.40	16.0	16	32.8	22.5	20.6	65.8	2.7	18.49	31.12	9.72	486
1972	10.40	16.0	16	32.8	25.5	24.9	79.7	4.6	16.31	25.71	8.03	288
1973	10.40	16.0	16	32.8	37.0	33.6	115.3	4.6	11.24	19.07	5.55	288
1974	10.40	16.0	16	32.8	37.0	47.8	102.7	5.6	11.24	13.39	6.23	233
1975	10.40	16.0	16	32.8	37.0	47.8	123.7	6.2	11.24	13.39	5.17	213
1976	10.40	16.0	16	32.8	39.7	55.7	144.7	6.2	10.49	11.48	4.42	213
1977	10.40	20.0	16	32.8	39.7	59.5	159.7	6.2	10.49	10.76	4.01	213
1978	12.10	25.6	20.0	41.0	48.2	64.3	159.7	6.2	10.03	12.44	5.01	266
1979	12.10	25.6	26.4	51.2	50.0	64.3	159.7	7.5	9.68	15.93	6.61	273
1980	15.13	28.8	26.4	51.2	58.0	75.0	171.0	9.7	10.43	13.65	6.18	212
1981	21.60	32.0	28.0	64.0	58.0	85.0	178.0	9.7	14.90	13.55	6.29	265
1982	21.60	32.0	33.6	64.0	64.0	88.0	183.0	9.7	13.50	14.55	7.34	265
1983	21.60	32.0	33.6	64.0	64.0	90.0	186.0	9.7	13.50	14.22	7.23	265
1984	21.60	32.0	33.6	64.0	70.0	90.0	189.0	9.7	12.34	14.22	7.11	265
1985	21.60	32.0	33.6	64.0	80.0	93.0	193.0	9.7	10.80	13.76	6.96	265
1986	21.60	32.0	33.6	64.0	80.0	102.0	193.0	11.8	10.80	12.55	6.96	217
1987	21.60	32.0	33.6	64.0	82.5	130.0	193.0	11.8	10.47	9.85	6.96	217
1988	21.60	32.0	33.6	64.0	85.0	135.0	196.0	12.6	10.16	9.48	6.86	203
1989	21.60	32.0	33.6	64.0	96.0	143.5	211.0	13.8	9.00	8.92	6.37	186
1990	21.60	32.0	33.6	64.0	112.0	150.0	245.0	15.3	7.71	8.53	5.49	168
1991	21.60	32.0	33.6	64.0	124.0	155.0	280.0	16.8	6.97	8.26	4.80	153
1992	21.60	32.0	33.6	64.0	130.0	175.0	300.0	17.5	6.65	7.31	4.48	146
1993	27.00	32.0	33.6	64.0	160.0	185.0	315.0	18.0	6.75	6.92	4.27	142
1994	29.70	66.5	38.4	133.1	160.0	210.0	400.0	20.5	7.43	12.61	3.84	260
1995	32.67	66.5	42.7	133.1	173.0	222.0	400.0	21.5	7.55	11.98	4.27	248
1996	44.93	66.5	47.5	133.1	240.0	255.3	500.0	24.0	7.49	10.42	3.80	222
1997	49.42	71.7	75.3	143.5	240.0	310.0	500.0	35.0	8.24	9.25	6.03	164
1998	54.36	79.7	83.7	159.4	264.0	330.0	825.0	35.0	8.24	9.66	4.06	182
1999	59.80	88.5	93.0	177.2	300.0	350.0	725.0	35.0	7.97	10.12	5.13	202
2000	59.80	88.5	93.0	177.2	300.0	385.0	725.0	36.0	7.97	9.20	5.13	197
2001	59.80	88.5	93.0	177.2	300.0	385.0	780.0	42.0	7.97	9.20	4.77	169
2002	59.80	88.5	93.0	177.2	300.0	385.0	800.0	42.0	7.97	9.20	4.65	169
2003	34.40	88.5	93.0	177.2	350.0	400.0	850.0	42.0	3.93	8.85	4.38	169
2004	34.40	88.5	93.0	177.2	400.0	415.0	975.0	42.0	3.44	8.53	3.82	169
2005	34.40	88.5	93.0	177.2	415.0	450.0	1025.0	45.0	3.32	7.87	3.63	157

Source: 1. Economic Survey 1997-98 and 2003-04, Finance Division, Government of Pakistan, Islamabad.
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