DROUGHT-MITIGATION INTERVENTIONS BY IMPROVED WATER-MANAGEMENT:
A CASE STUDY FROM PUNJAB - PAKISTAN

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ABSTRACT

The Paper describes the main features of the water-scarcity management plan that was implemented during the last two Rabi seasons, to optimize wheat-production in the Punjab province. Due to severe drought conditions in the country, the river-flows remained well below the normal range, resulting in overall 18% and 43% shortfall in canal-water supplies during the Rabi seasons of 1999-2000 and 2000-2001, respectively. In order to address the adverse impacts of the serious water-shortage, Punjab Irrigation Department formulated a comprehensive and action-oriented plan, in consultation with the Agriculture Department and the farmers' representatives. The main thrust of the plan focused on: conserving water during the slack demand periods and its reallocation during sensitive growth-stages, priority canal water allocation to the saline groundwater areas, and providing one to two waterings to the non-perennial areas.

The implementation of Rabi Plan was closely monitored throughout the crop-season by the senior irrigation-managers and the needed adjustments were made in timely response to the actual water-availability. The information regarding the Plan and its subsequent operation was disseminated through the media and the Extension Wing of Agriculture Department. In order to improve internal water-management regime, as well as to ensure farmers' participation in planning and efficient operation of the canals, water-Allocation Committees at the canal- command level and canal-division level were established throughout the province.

As a consequence of the innovative and bold water-management interventions, the province harvested bumper wheat–crops, despite serious water-shortages. The paper highlights the need for close and continuous monitoring of the planned operations, as well as, the significance of other non-water inputs, like realistic support-price, timely sowing of wheat, improved availability of fertilizers, better seeds, and efficient extension services. The experience of last two crop-seasons has demonstrated that considerable scope exists for optimizing the water- management at macro and micro-levels. It also brings into focus the importance of advance resources-planning, timely dissemination of the information regarding canal-operations and local-level water-management for mitigating the impacts of droughts.

THE SETTING

Pakistan has the distinction of having the largest contiguous gravity-flow irrigation-system in the world. The irrigation-system serves as a lifeline for sustaining the agriculture in this part of the world, having arid to semi-arid climate. Irrigated lands supply more than 90 per cent of agricultural production, account for 25 per cent of GDP, and employ per cent of labour force. They supply most of the country's needed food-grain and also are the source of raw materials for major domestic industries.

Irrigation in the Indus Basin has a long history, dating back to the Indus Civilisation. Irrigation development on a scale unknown in history, however, started about the middle of 19th century under British rule. The inundation canals were first improved, and then gradually converted to properly- regulated perennial channels, by means of weirs and barrages constructed across the rivers. Large inter-basin link canals and storages were subsequently constructed, as a consequence of Indus Water Treaty in 1960s and the first half of 1970s The existing storage capacity of Tarbela and Mangla reservoirs, constructed as a sequel to Indus Water Treaty, is rather small; being less than 10% of the average annual river flows. The construction of these storages and link canals allow operation of the Indus-Basin Irrigation System in a more integrated manner, with greater control and flexibility. This, however, requires comprehensive advance planning and technical expertise to optimise canal operations (Haq, 1998).

The Punjab Irrigation network was designed as a 'protective' system, with low cropping intensities. However, over decades of canal-system operation and as a consequence of rapid growth of population, the irrigation demand has increased way beyond the

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designed capacities. The Irrigation network of the Province comprises 21canal-systems, about 8000 km of drains, 6000 large-size public tubewells and around 500,000 small-capacity private tubewells, 31 small dams and an extensive flood-protection infrastructure. There are 14 major barrages on the five rivers flowing in the heart of this valley, with a total off-take canal capacity of 3400 cusecs of irrigation supplies and another 3100 cusecs capacity of inter- river links. The colossal canal network provides irrigation facilities to 8.5 Mha of fertile lands in the Punjab. Of this, 5.3 Mha receive year-round (perennial) supplies, while 3.2 Mha get canal water only during six summer months (non-perennial canals). There are two main crop- seasons, i.e. Summer (Kharif) and Winter (Rabi). Cotton, sugarcane and rice are the main Kharif crops, while wheat is the principal Rabi crop. The groundwater development, by means of small-capacity private tubewells, has played a significant role in supplementing irrigation-water supplies during the last three decades and, in most of the Fresh Groundwater areas, the tubewells are contributing around 40% of the overall irrigation water requirements (PGC, 2000).

WATER MANAGEMENT REGIME

The waters of the Indus Basin Rivers stand apportioned between the four Provinces of Pakistan, through the Water Apportionment Accord of 1991. The province-wise Accord allocations are presented in Table-1, while the historic uses (1977 – 82) are given in Table - 2 (GOP, 1991). The Indus River System Authority (IRSA) was established in 1993 for water-allocation and the implementation of the Water Accord. This Authority prepares the forecast of water-availability for each crop-season i.e. Kharif and Rabi, and determines the provincial shares, in accordance with the provisions of the Water Accord. The Provincial Irrigation Departments formulate the canal regulation program for the crop–season, according to the provincial shares intimated by IRSA. If the available share is less than the crop requirements, a canal rotational program is prepared, to distribute the available supply equitably over the entire canal-system. Water- Allocation Committees, comprising representatives of Irrigation and Agriculture Department, as well as representatives of the farming community, are constituted at all the main canals and branch canals level to

Table –1: Accord Allocations*

Province	Kharif (BCM)	Rabi (BCM)	Total (BCM)
Punjab	45.6	23.21	68.81
Sindh**	41.75	18.23	59.98
NWFP	4.28	2.83	7.11
Civil Canals***	2.21	1.48	3.69
Baluchistan	3.51	1.25	4.76
Total	**95.14**	**45.52**	**140.66**
	+	**+**	**+**
	2.21**	**1.48****	**3.69****

*Note: * Para 2 Allocations*

*** Including already sanctioned Urban and Industrial uses for Metropolitan Karachi*

****Un-gauged Civil Canals above the rim stations.*

Table-2: Actual Average Historic Uses-1977-82

Province	Kharif (BCM)	Rabi (BCM)	Total (BCM)
Punjab	42.62	24.29	66.91
Sindh	35.41	18.34	53.75
NWFP	2.24	1.59	3.8
Baluchistan	1.59	1.01	2.6
Total	**81.83**	**45.23**	**127.06**

formulate, approve and monitor the implementation of the rotational programs.

WATER AVAILABILITY DURING LAST TWO RABI SEASONS

Drought conditions were experienced in Pakistan during the last two years; the water shortage was particularly severe during Rabi 2000-2001. The monsoon rains were also erratic and below normal in the canal-irrigated areas. The initial forecast of water-availability prepared by IRSA indicated that the expected water-availability for Punjab canals during the Rabi period 1999-2000 would be about 20.9 BCM, against Punjab Accord share of 23.2 BCM and projected requirement of 27.1 BCM. The actual water-availability was, however, only 20.2 BCM (18% shortfall with respect to historic uses). The water-availability position became even worse during Rabi 2000-2001 and so canal-withdrawals were restricted to only 13.90 BCM, which means that an extremely severe (43%) shortage was encountered. The Punjab Canals Rabi-withdrawals for the 1990-91 to 2000-2001 decade are shown in Table-3 (PID, 2001).

Table - 3: Punjab Canals Rabi Withdrawals (1990-91 to 1999-2001)

Year	Water Allocation (BCM)	%Age Diff. w.r.t. Average (+/-)	%Age Diff. w.r.t. Historic(+/-)	%Age Diff. w.r.t. Accord (+/-)
1990-91	27.43	17.83	12.23	18.18
1991-92	23.79	2.2	-2.66	2.5
1992-93	26.17	12.41	7.08	12.75
1993-94	23.06	-0.95	-5.65	-0.65
1994-95	25.21	8.3	3.15	8.62
1995-96	25.94	11.43	6.14	11.76
1996-97	24.55	5.46	0.45	5.77
1997-98	22.64	-2.75	-.7.36	-2.46
1998-99	23.23	-0.21	-4.95	0.09
1999-2000	20.2	-13.23	-17.35	-12.97
2000-2001	**13.9**	**-40.3**	**-43**	**-40.1**

RABI PLAN, 1999-2000 AND 2000-2001

In order to address the adverse implications of this serious water shortage, PID/PIDA formulated an action-oriented and comprehensive "Rabi Plan", in active consultation with the Agriculture Department and the farmers' representatives. The main thrust of the Plan focused on the following innovative and bold concepts:

1. Conserving water during the slack-demand period and re-allocating it during the critical / sensitive crop-growth stages.
2. Priority canal-water allocation to the Saline Groundwater (SGW) areas, which cover about 30% of the irrigated lands in Punjab.

Box -1: Rabi Plan 1999-2000

- All non-perennial canals in cotton-zone were closed from 5th Oct., instead of 15th October.
- All perennial canals in cotton-zone were closed from 15th to 31 Oct.
- The flow-period of NP canals in rice-zone was extended from 15th Oct. to 31 Oct.
- All perennial canals in rice-zone were closed from 1st to 15th November.
- 15 days watering in non-perennial canals in the cotton-zone was released from 20th Nov. to 5th December.
- All perennial channels were run with 10% shortfall during January to 10th February 2000, to remain within Punjab share.
- All perennial channels were closed for a period of 20-22 days during the month of January 2000, to undertake O&M of the Barrages / Main canals and distributary system, as well as save water for use subsequently.
- All perennial channels in Mangla/Tarbela Command were raised to full capacity from February 11 to February 29, so as to provide crucial watering during the development stage of wheat-crop.
- All Non-perennial channels were given full watering for 15 days from February 21 to March 5.
- All perennial channels were reduced to 60% capacity from March 6 to March 31, to remain within the provincial share.

BOX - 2: RABI PLAN 2000 – 2001

- ❖ All the Non-perennial canals in Cotton Zone were closed 15 days in advance (01 October instead of 15 October).
- ❖ All perennial channels in Cotton Zone closed for 3 weeks (10-31 October).
- ❖ Extension of flow period of NP channels in Rice-Zone by 5 days (upto 20 October).
- ❖ 10 days closure of all Perennial channels in Rice Zone.
- ❖ Two weeks watering in Cotton Zone for Wheat-Sowing (20 November to 05 December).
- ❖ Perennial Canals running
  - 55% Capacity: Upto 15 February
  - 70% Capacity: Upto 28 February
  - 30% Capacity: During March
- ❖ Non Perennial Channels: Closed

3. Providing one to two waterings to the non-perennial canal command areas.

In order to implement the above strategies, the broad pattern of canal regulation / management (see Box-1) was planned to optimize the water use.

The implementation of Rabi Plan was closely monitored throughout the crop season by the senior irrigation-managers and the needed adjustments were made timely, in response to the actual water-availability. The information regarding the Rabi Plan and its subsequent operation was disseminated through the media and the extension wing of Agriculture Department

INTERNAL WATER-MANAGEMENT AT CANAL-COMMAND LEVEL

In order to improve internal water-management regime, as well as to ensure farmers' participation in planning and operating the canals, for equitable and efficient distribution of irrigation water, Water Allocation Committees at the Canal Command level and at the Canal Division level were established throughout the Province, as below (PID, 2000):

BOX- 3: Canal Command Level Water-Allocation Committees

Composition:

i)	Superintending Engineer	Convener
ii)	Director of Agriculture or his representative	Member
iii)	Representative of Deputy Commissioner	Member
iv)	Three Farmer' representatives from the head, middle and tail reaches of the canal system	Members

Functions:

i) Receive share of each main canal-system from the Directorate of Regulation for each crop season viz. Kharif and Rabi

ii) Prepare the water-distribution program on 10 – day basis, taking into consideration the Accord-allocations, cropping-pattern and crop water- requirements.

iii) Review and monitor the actual operation of the Canal System with reference to the water-account, vis-à-vis. the canal share.

iv) Devise ways and means to streamline and improve the water-management operations and affect equitable distribution of available supply.

Divisional Water-Allocation Committees

Composition:

i)	Executive Engineer	Convener
ii)	Assistant Director Agriculture or his nominee	Member
iii)	Assistant Commissioner or his nominee	Member
iv)	Three farmers' representatives from the head, Middle and tail reaches of the system	Members

Functions:

i) Receive the share of each canal division from the Superintending Engineer.

ii) Formulate regulation / rotational programs of the distributaries and minors in the canal–division, for affecting equitable distribution of the available supply.

iii) Assess the canal-water demand in a crop season and assist the Executive Engineers in determining the indents of various channels on 10-day basis.

iv) Monitor the operation of the canal-system in the division and review the water-Account vis-à-vis. the allocated share.

WATER MANAGEMENT IMPACT ON WHEAT PRODUCTION

As a consequence of the innovative and bold water-management interventions, complemented by improved agricultural practices and incentive offered by enhanced support-price, the province harvested a bumper wheat crop. The following analysis demonstrate the overwhelming impact of water-management optimization on the record wheat-production (GOPb, 1999; GOPb, 2001):

- The Wheat-crop figures for the last 10 years presented in Table-4 show that, despite 18% water-shortage during 1999-2000, the area under wheat increased by about 5% and the wheat-production increased by 28% over the last 10 years' average. Although wheat area and production declined during 2000-2001, compared to 1999-2000 bumper crop, yet the cropped area was 3% more than last 10 years average, while the crop-production was 18% higher than the last 10 years average production despite the most serious drought-conditions, which resulted in 43% shortage of canal water.

- It may be noted that the wheat-production in the un-irrigated areas declined by about 5% during 1999-2000 over last five years average, due to erratic rainfall during 1999-2000 (Table-5).

- The wheat production in four selected SGW districts, where canal-water is the only source of irrigation, increased by 27-40% during 1999-2000 over the corresponding last year figures (Table-6). This clearly demonstrates the positive impacts of priority water-allocation to SGW areas.

Table - 4: Last 10 Years Wheat Crop Figures

Period	Area (Mha)	Production (M.Tons)	Average Yield (Tons/ha)
1990-91	5.71	10.51	1.84
1991-92	5.67	11.49	2.03
1992-93	5.96	11.74	1.97
1993-94	5.77	11.21	1.94
1994-95	5.9	12.71	2.15
1995-96	5.97	12.43	2.08
1996-97	5.84	12.37	2.12
1997-98	5.94	13.81	2.32
1998-99	5.94	13.21	2.22
1999-2000	**6.18**	**16.48**	**2.67**
2000-2001	**6.08**	**15.2**	**2.5**
Average	**5.91**	**12.84**	**2.17**

Table – 5: Last 5 Years' Wheat Crop Figures for Irrigated and Un-irrigated Areas

Crop	Irrigated Area		Un-Irrigated Area		Total	
	Area *(Mha)*	Production *(M.Tons)*	Area *(Mha)*	Production *(M.Tons)*	Area *(Mha)*	Production *(M.Tons)*
1995-96	5.26	11.49	0.713	0.936	5.97	12.43
1996-97	5.08	11.57	0.76	0.801	5.84	12.37
1997-98	5.21	12.59	9.725	1.22	5.94	13.81
1998-99	5.23	12.16	0.705	1.045	5.94	13.21
1999-2000	**5.46**	**15.53**	**0.71**	**0.94**	**6.18**	**16.48**
Average	**5.25**	**12.67**	**0.72**	**0.98**	**5.97**	**13.66**

Table - 6: Wheat Area and Production in Saline Groundwater Areas

District	1998-99		1999-2000		%age increase	
	Area (Mha)	Production (M.Tons)	Area (Mha)	Production (M.Tons)	Area (Mha)	Production (M.Tons)
Faisalabad	0.24	0.55	0.25	0.77	4.1	40
TT Sing	0.14	0.35	0.14	0.47	0	34.2
Kasur	0.16	0.4	0.17	0.51	6.2	27.5
Bahawalpur	0.27	0.55	0.28	0.71	3.7	29

CONCLUSIONS

The following main conclusions can be drawn from the experience gained out of the water-scarcity management programme undertaken by the Punjab Irrigation Department / PIDA during Rabi 1999-2000 and Rabi 2000-2001. The management-interventions were unique in the sense that they were implemented on an unprecedented mega–scale, involving over 8.5 million hectares of the commanded area in the Punjab.

1. It has been demonstrated that considerable scope exists for optimizing the water-management / allocation at macro-level. It also brings into focus the significance of the following optimization alternatives:

    - Re-allocating water within the crop–season, to better match the crop water-requirements. Additional canal-closures can be planned for the purpose during the slack-demand periods. This also helps in improving the drainage-environment in the root-zone, particularly in the waterlogged areas.
    - Allocating preferential canal-supply to the saline groundwater areas.
    - Priority-water allocation during sensitive / critical crop-growth stage.
    - Providing one to two canal-watering to non-perennial areas, which traditionally do not receive canal-supplies during the Rabi season.
    - Conjunctive groundwater use.

2. Importance of advance resource–planning, in collaboration with all the stake-holders (Irrigation Department, Agriculture Department, Water-Allocation Committees, etc.) is brought out. The advantages / need for timely dissemination of the information regarding canal-operation plans to the farmers is also highlighted.

3. Local-level management, through canal-command and canal-division level water-allocation committees can further enhance the beneficial impacts of the improved management regime.

4. Close and continuous monitoring of the planned operations, along with timely adjustments in response to the actual water–availability, hold the key to the successful implementation of an overall water-management regime. This is also critical for obtaining the desired enhancement in the levels of production.

5. The following non-water factors also contributed towards the record wheat-production during the 1999-2000 Rabi season:

    - Enhanced Support Price of wheat (from Rs 240 to Rs 300 per 40 Kg)
    - Timely sowing of wheat
    - Improved availability of fertilizers, better seeds and efficient extension- services, etc.
    - Favourable weather-conditions at the time of crop-maturing.

6. The enhanced dependence on GW has resulted in considerable depletion of Aquifers and increased burden on farmers, because of high cost of Pumped Water.

7. The successful model of water-scarcity management during Rabi 1999-2000 has been a good learning experience, which has been replicated quite effectively during the Rabi 2000-2001 crop, also, in the face of a much more severe water shortage.

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