



CASE STUDY FROM
PAKISTAN

SURVEY ON IRRIGATION MODERNIZATION

Pehur High Level Canal Project

Prepared by Zaigham Habib

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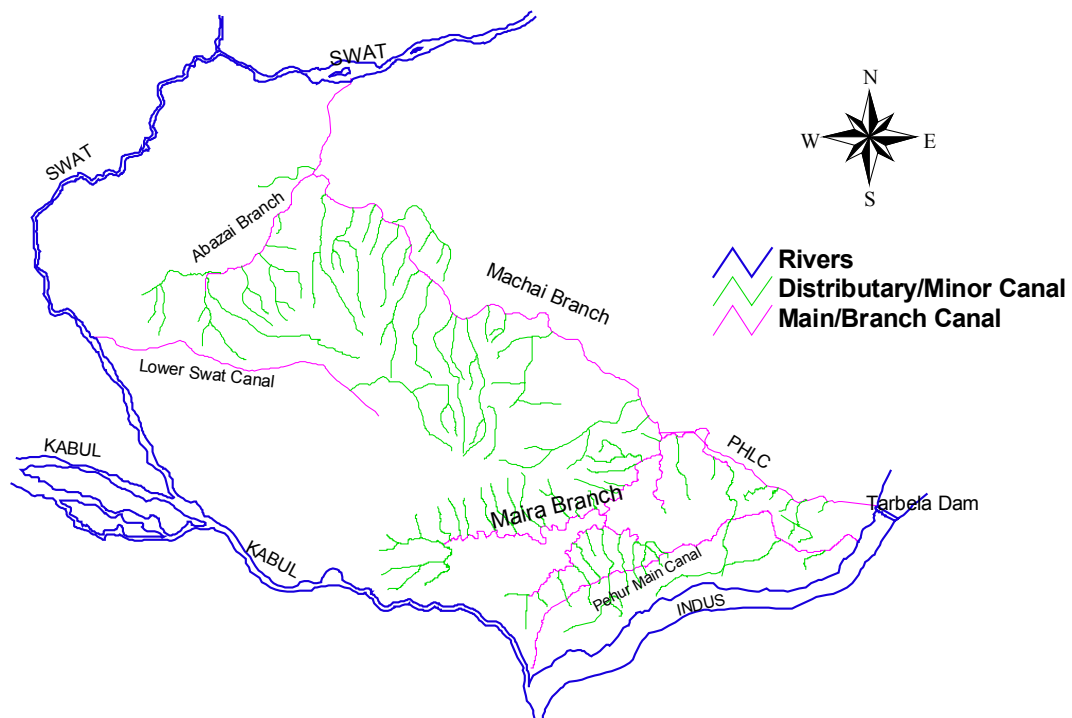
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Case Study of Samrat Ashoka Sagar Project on Halali River, Madhya Pradesh, India

By Ganesh Pangare, Rajat Hooja and Nitin Kaushal

1 PART A. SYSTEM DESCRIPTION (LAYOUT)



1.1 Background and Project Location

During construction of the Tarbela Dam Project, between 1968 and 1974, a decision was made to provide an irrigation supply tunnel through the right abutment of the dam, later on to provide irrigation supply to the rain fed areas lying in the adjacent districts of the Tarbela Reservoir. The implementation of the project was delayed due to provincial dispute on the division of Indus river waters. In March 1991, the Water Apportionment Accord was signed by the provinces, which allocated about two billion cubic meter water to the North West Frontier Province (NWFP). In May 1994, Government of Pakistan approved Pehur High Level Canal (PHLC) Project to provide supply to the rain fed areas of Topi district of NWFP and to enhance supplies of Upper Swat Canal System (USCS) with a gross water allocation of 0.645 bcm from Tarbela reservoir. The Project implementing agency was Water And Power Development Authority (WAPDA). The Asian Development Bank (ADB) agreed to fund 80% of the project cost approved as a Loan (No. 1294 - PAK) in 1994.

The project area is located on the right bank of the Indus River immediately downstream of Tarbela reservoir and lies in Swabi and Noshehra Districts of North West Frontier Province (NWFP) of Pakistan. It extends between 72° 05' / 72° 42' N and 34° 01' / 34° 10' E. As Pehur canal feeds USCS, the area of its influence extends. The command area is bounded by the Swabi Hills on the North East, Pehur main canal and Kabul river in the South, Kalpani river on the west and Ballar Drain on the north west. It is a part of Kabul-Swat-Chitral basin towards east of the Peshawar valley. The topography of the area is diverse with four physiographic sub-regions namely Mardan plain, Swabi plain, Sar-i-maira and Barani river.

1.2 Command and irrigated Areas

The direct beneficiary area of the project, consisting of existing and new Canal Command Area (CCA), is about 40,900 ha.. About 6,000 ha of waterlogged land within the Project boundary would be reclaimed. According to the project estimations, indirectly benefited area is 72,000 ha (Table 1). It includes the command areas of other system currently fed by the Swat river.

The current cropping intensities of the Upper Swat System (USC) are about 145% (in 1994, surveyed cropping intensities were 140%, National data of crop census shows 5% increase for the area). The cropping intensities of the rain-fed area were officially monitored in 1988 as 30%.¹ The design cropping intensities of the new area are 175%, while intensities in the remodelled USC system are officially increased from 80% to 160%.

Land Tenure Structure

Complete land tenure information could not be compiled, however based on the gross annual reports and information provided by the local project staff:

- In USC command, 70% of the land owners are small holders, i.e land holding less than 5 ha.
- In Topi priority area, land holdings are large, about 75% owning up to 50 acres, while 25% are small farmer-owners.
- The tenant are mostly land less sharecroppers. In the rain-fed area they receive 25% of the harvest, while in the more settled areas up to 50% (half share).

1.3 Dates Build

The Upper Swat System (USC) was build in 1915 and fully operated in 1920. The upper half of USC has been remodeled between 1997-2001, its lower half is in the process of remodeling. The Pehur Canal system is under construction.

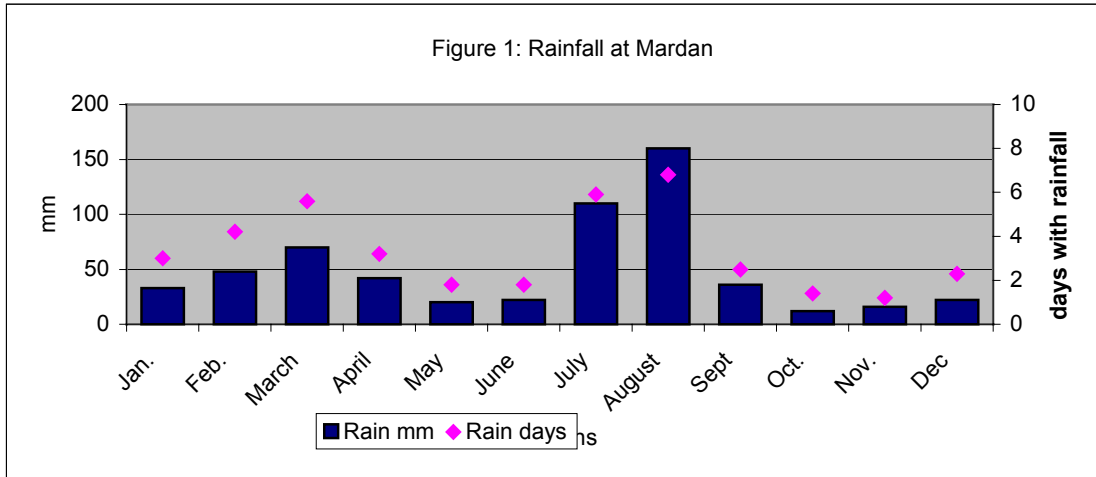
1.4 Water Resources

Rain

Mean annual rainfall in command area varies from about 500 mm in the west to 1100 mm towards north-east. About 75% of the total rain falls within two distinct periods: February-April, and June-July. The winter rain is mainly due to depressions moving east across the region from the Middle East, while monsoon in summer. The rainfall pattern of Mardan city, which is towards

¹ A good crop cultivation is seen during the field trip, based on brief discussion with local people, the actual cropping intensities now are about 80%.

dry zone, is shown below. The number of days with rain is more than 40, scattered over all months. Total rainfall volumes and rain-storm intensities at Tarbela are used to calculate run-off capacity of surface drainage structures. The percentage runoff (ratio between excess/gross precipitation) from drainage sample areas vary from 44% to 80%.



The contribution of rain in meeting crop needs is not explicitly considered in the calculations.

River water

Two surface water sources are considered primarily for irrigation supply to the project area: diversion on Swat River at Amandara and releases from Tarbela reservoir. The minimum recorded flow of 1 in 5 year and the average flows are used to estimate water availability from the Swat river. Principally, PHLC can draw 0.645 million cubic meters water from Tarbela, regardless a gross water shortage or the supply to other systems. However, practically, this volume could be less in a draught year. Expected uses and allocation according to the revised PC-1, 1997 are:

Swat River Uses	between 350 to 260 MCM
Tarbela Reservoir diversions	between 417 to 353 MCM
NWFP Allocation from Tarbela	645 MCM

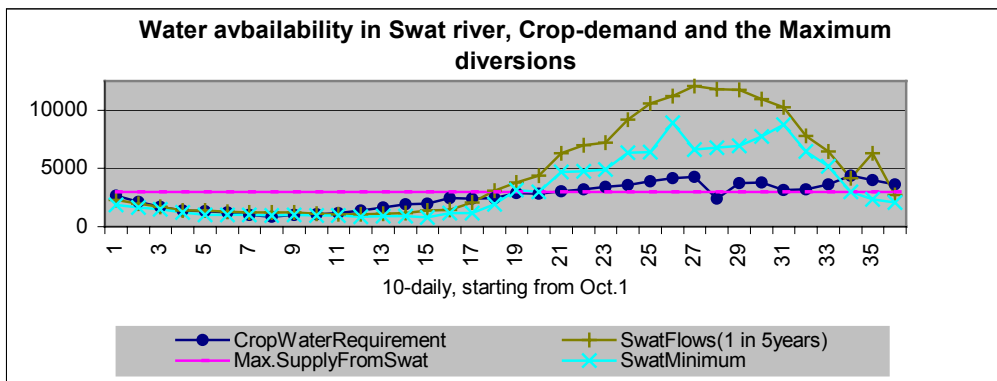


Figure 2: Water Availability from Swat river and expected crop demands at full development

The abstraction from Swat River would be influenced by the water abstracted/used by small communities and private business (mostly hotels, resorts) upstream of Amandara, with flows passed on to the lower Swat system and capacity of the Amandara head regulator. No water shortage is expected due to these uses. Most of the private business is draining effluent back into the river, which can cause a quality constraint. The groundwater contribution is not considered in project planning or in the estimation of water availability. The water availability from the Swat River is shown in Figure 2.

Salient Features of the PHLC Project		
1.	Location	Swabi ,Mansehara Districts of NWFP
2.	Type of Project	Irrigation-cum-Drainage
3.	PHLC Capacity	28.4 m ³ /sec
	New Irrigation (Topi Area)	5,100 ha
	Allocation at the head of watercourse	11 cusecs/1000 acrss 0.77 l/s/ha
	Area benefited from remodeling of Upper Swat Canal	35,800 ha
	Old allocation at the head of watercourse	5 cfs/1,000 acres or 0.35 l/s/ha
	New allocation at the head of watercourse	9 cfs/1,000 acres or 0.63 l/s/ha
4	Direct Beneficiary Area	40,900 ha
5	Indirect Beneficiary Area	79,800 ha
6	Reclamation Through Drainage	6,000 ha
7	Project Components	
	New Pehur High Level Canal	31.3 km
	Gandaf Pressure Tunnel	3.9 km
	Baja Gravity Tunnel	1.2 km
	Main Canal, Parabolic and Lined	26.2 km
	Remodeling of Existing Channels	132.0 km
	Improvements to Existing Channels (excluding ii)	86.0 km
	Downstream control gates/regulators (Avio & Avis)	12
	in Pehur canal	5
	in Lower Swat Canal	7
	Escape Channels, Combined Capacity of Two	
	Improvement of Surface Drainage	280 km
	Sub-surface Drainage in Pehur DSA	6,000 ha

1.5 System Type

According to the *protective versus productive* nomenclature, crop based system are considered productive irrigation systems. However, these terms does not explain the difference between PHLC and other systems of the basin. The irrigated agriculture supported by the project could be called “*supply flexible crop based, designed for the optimal cropping intensities*”. For the nature of irrigation and conveyance infrastructure, USC-Pehur system can be further divided into three sub-groups.

New command area (Topi)

Officially demand-based with physical capacity to draw double than computed crop water requirements on 10-day interval for 175% annual cropping intensities. A pilot area with full “bottom-top” management controlled by farmer’s pipes fitted with Harris float valves directly offtaking from downstream controlled main canal, with the rest of the system having proportionate dividers at watercourse head. Supported by the reservoir.

The Lower half of the USC-PHLC System

Crop-based with generous capacity, minimum infrastructure restriction, operated by downstream control gates in the main canal, upstream control radial gates at the secondary canals and proportionate dividers at the tertiary level. Supported by the reservoir.

The Upper half of USC System

Upstream controlled crop-based with abundant water supply most of the time. The design capacity at the maximum allocation while the flow is not supported by the reservoir. The supply could be constrained by low Rabi flows in Swat river in winter.

1.6 Energy Source

The energy resource to the project command area is Tarbela Reservoir

1.7 Water Rights

The entitlement to irrigation water is attached with land as other systems of the Indus basin. The actual water receive by a farm will be determined by a combination of: a) water allocation, which is 0.7 l/s/ha and 0.63 l/s/ha, respectively for new and remodelled CCA, b) 10-daily scheduled diversions approved by Indus River System Authority (IRSA) varying from 0.22 l/s/ha to 0.7 l/s/ha, c) physical capacity and operations of the system.

The envisaged operation of the system are a) demand-based in the Topi Priority Area and, b) crop- based in rest for the system. Which means, farmers could draw a quantity of water controlled by the capacity in TPA and based on 10-daily scheduled diversions in other areas. The given 10-daily diversions are based on proposed cropping patterns, while no measure is planned to restrict the cropping patterns. Hence, in the design setup, if the system could be operated at variable flows at the secondary and tertiary level, then:

1. water rights are equivalent to allocation in 5% demand based area, and
2. equivalent to 10-daily scheduled supplies in 95% of the project area.

However, operations of the crop-based systems in Pakistan show that a strict rotation could not be implemented in these systems (Garces, CRBC Report 1994). As, the physical capacities of all components are more than peak demand of fully developed system, actual water extracted by the farmers (hence de facto water rights) could be higher than their actual maximum demand. Even, if a rotation is applied for half of the year (when demand is less than 60%), most of the time during the year, farms will have the “right” to extract more water than the design irrigation

requirements. So, water rights of crop-based areas are more influenced by the capacity and allocation (both are not the same but we can say allocation in the end) than the proposed schedules.

1.8 Water Fee

1. Water Fee Structure: Water fee is based on reported cropped area and crop type. For example, each cropped ha of wheat will pay about 4 US\$. In each village, a semi official person (*Lamberdar*) collects this money. He is not a public sector employ, but, appointed by the Government. His remuneration is based on the revenue collected. It must be noted that water fee is marginally but consistently increased in the previous decade. During the last two years efforts have been made to enforce another “differential agriculture Tax” (Provincial Budgets 2001), which excludes “small farmers” and includes crop and soil types. The tax is still not well placed in all Provinces.
2. According to the Canal Act of NWFP, all users must pay water fee. In case of non payment some penalty exists. However, political/tribal interference makes it difficult to take actions.
3. All big systems of NWFP has gone through remodeling or construction during last 10 years, hence O&M cost is paid under project items. An accurate relation between O&M and water fee is very difficult to assess at this stage.
4. No extra payment if foreseen. Maybe it is not even justified in the context of additional water, because this water is not requested by the farmers, rather imposed by a “good piece of Engineering”. The farmers has shown resentment against enlargement of watercourses and introduction of demand-based system at the tertiary level. One of the reasons behind their protests is apprehension that the Government can impose a fee based on the volume of water used.
5. The use of fertilizers/pesticides and agriculture machinery is relatively low in the area. Based on the standard practices, cost of water is about 10% of the inputs in case of wheat and less than 5% in case of cotton and sugarcane.

1.9 Topography and Soils

The major land farm features of the Mardan and Swabi are the rolling sand/silt plain with an average elevation of 350 m above sea level. Near the mountain and rock outcrops at the foot of the Swabi hills the land is more undulating and here the elevation rises to around 375 m. A substantial part of the project area, Sar-I-maira and Barani river sub-regions, falls in a nearly level basin plain. The area has a variable general slope to the south-east direction. The tunnel areas adjacent to Tarbela are mountainous and hilly with a maximum elevation of 650 m at Gandaf (tunnel site).

For the permeability estimation, soil is divided into 5 categories, clayey silts, silts, gravely silts, silty gravels and gravels. The design value for the permeability is taken 1×10^{-6} m/s for silty material, 5×10^{-5} m/s for gravely material and 1×10^{-3} m/s at the outlet of Gundaf tunnel.

1.10 Crops

Principal crops grown in the Project area are wheat, maize, sugar cane and tobacco. Wheat is the principal crop grown in Rabi season (November to March inclusive) and maize is the principal crop in Kharif season (April to October). Potato, fodder, some oilseeds and vegetables are also grown in Rabi season while additional fodder and vegetables are grown in Kharif. Orchards, plums, apricots, pears and some citrus fruits, are grown in irrigated and rainfed areas.

1.11 Infrastructure Type

Some of the infrastructure information are given in Table-I. The extended and remodelled system is a combination of upstream controlled gravity flow alluvial and downstream control lined channels. The irrigation infrastructure consists of a power tunnel from the reservoir, parabolic lined and trapezoidal alluvial main canals partially downstream-controlled, upstream-controlled gravity flow secondary canals, proportionate tertiary outlets for 95% of the system and pipe outlets controlled by Harris valves to 5% of the system.

- ✓ The Pehur High Level Canal offtakes from Tarbela through a 4.7 km long power tunnel. It is a 24 km long lined parabolic canal of 28.4 cumecs capacity, downstream-controlled and having provision for future irrigation of 6,500 ha through lift schemes.
- ✓ The Gandaf tunnel, from Tarbels reservoir is designed as a pressure tunnel instead of gravity to have future hydropower generation through an off-line power station and to reduce the pumping cost of the lift irrigation scheme lying immediately to the north of the tunnel outlet.
- ✓ The PHLC joins Upper Swat system almost at the middle of it. The PHLC and the lower part of USC system are downstream-controlled with AVIO & AVIS float gates.
- ✓ Two big escapes and many small escapes are provided in the system, which could drain the canal in case of emergency.
- ✓ The Upper branch of the USC system is upstream-controlled with radial gates.
- ✓ The Topi Priority Area is provided with downstream control in the main canal and farmer's pipe outlets directly offtaking from the main canal and controlled by Harris float gates.
- ✓ "Supply refusal gates", in combination with proportionate dividers are proposed as an option for further evaluation.

In the project design, no groundwater use is expected, because appropriate topography and drainage potential is available to handle excess water (Chief engineer) . However, currently, groundwater is used in the rain-fed areas.

1.12 O&M

Operations:

In case of PHLC, two important levels of decision making are: a) farmers water extraction patterns and, b) diversions to the main canals from Swat River and Tarbela reservoir. Lot of flexibility and many operational combinations may be followed, even with a change during the year. At a particular time, the system can draw excess and drain it through escapes or refuse to take supply from one of the source or try to match combined resources with demand. In some areas, farmers can use groundwater, as a continuity of existing practice.

Some of the operational options have been discussed by the design consultants in their working papers numbers 9 and 16. These options are mainly: a) optimization of Swat or Tarbela waters with and without future power project on the canal, b) Type of rotation in Upper Swat main canal, c) rotational plans for the secondary canals and d) scope of "refusal gates" on watercourse heads. A more elaborate discussion and comparison are provided on "the rotations in Upper Swat" and options for using Tarbela water. More critical issues like "refusal gates", "operations on the full or variable supplies" are mentioned to be evaluated by the International Water Management Institute Pakistan (IWMI). Who will develop "computerized operational plan" of the system during a three years contract.

A draft "Operations Manual" has been prepared by the design consultants, which will be finalized by IWMI.

The main operational issues of the system are:

- a) Type of rotation in the upper portion of the Upper Swat during low demand period
- b) The need for acceptance and the type of rotation in the secondary and tertiary canals in whole project area
- c) The minimum continuous supplies technically possible in the secondary system and the consequential tertiary operations acceptable to the users
- d) Operations of the water courses in areas other than Topi Priority area, especially developing compatibility between farmers practices and extreme flow conditions.
- e) Water release patterns through Gandaf tunnel with and without hydro-electric power station at the downstream.
- f) Criterion and appropriate supply hydrographs to maximize one of the main source, e.g, i) Swat river diversions, while saving Tarbela water for other systems outside NWFP, or, ii) Tarbela water to match full allocation while maximizing other Swat water uses/diversion like downstream system of Lower Swat, upstream civil and private uses or diversions to the drainage.
- g) Making use of Tarbela water for power generation at hydroelectric station (if it is build) when water is being discharged down the dam spillway, and making a corresponding reduction in use of Swat river water.

The final operational procedures will depend upon the choices of the operational authority and the acceptance of the water users. Two constraints play the primary role, the required intensity of management and a Provincial policy to have its share from Tarbela..

Maintenance:

The Provincial Irrigation Department is responsible for the maintenance of irrigation network. The Gandaf tunnel and Butter-fly gate at its opening are part of the reservoir and hence WAPDA's jurisdiction. A draft Maintenance Manual prepared by the design consultants is improved during construction phase, and the maintenance procedures will be finalized during first few years of system's operations. The Irrigation Department has engaged IWMI as consultants to finalize O&M procedures and manuals.

The transfer of maintenance to water users above watercourse level is not planned at this stage. As, the system is new and more complicated, willingness of farmers to operate it could not be anticipated.

1.13 Monitoring and Evaluation

A detail M& E is proposed and implemented up till now. Comprehensive surveys on hydrology, water availability, soil conditions and agriculture are carried out during feasibility studies, design and construction phases, including:

- ✓ A base line survey was carried out in 1994-95
- ✓ A socio-economic survey of vulnerable groups in the PHLC Project area
- ✓ Environmental and Benefit M&E (EBME) by the concerned WAPDA agencies
- ✓ Subsurface hydrology, soil and water quality monitoring;
- ✓ Surface hydrology and meteorological monitoring.

According to PC-I Proforma (Appendix 1): *The evident aim of M&E is to make possible a comprehensive and integrated evaluation of the impacts of all the planned interventions in the system. The Project's Monitoring and Evaluation (M&E) Component focuses on assessing (i) impact on agricultural output, farming practices and income; (ii) the performance of the irrigation and drainage facilities; (iii) the Project's effects on socio-economically disadvantaged groups including tenants, landless labourers and women; and (iv) establishing a causal link between Project interventions and inferred agricultural and social impacts.*

The following surveys are recommended to be carried out during the operational phase:

- ✓ seasonal surveys: agro-economic surveys including seasonal household and watercourse conveyance efficiencies;
- ✓ monitoring of flows in irrigation canals and surface drains
- ✓ project specific agro-meteorological data; and
- ✓ monitoring groundwater table and the quality of groundwater and drainage water and soils;
- ✓ Socio-economic impact after the Project interventions.

The departments involved in M&E are:

- ✓ Provincial Irrigation Development Authority (PIDA)
- ✓ SCARP Monitoring Organisation (SMO)
- ✓ The Watercourse Monitoring and Evaluation Directorate
- ✓ Surface Water Hydrology Project for the flow and agro-meteorological monitoring Environmental Cell, Planning Division
- ✓ The consultants for socio-economic subprogram.

2 PART B. MODERNIZATION PROCESS

2.1 Causes that led to system's modernization

- Change of approach recommended by the sector and basin level studies carried out in seventies and eighties provided the context for the modernization implemented in PHLC. These studies, financed by WB, UNDP and other international donors, repeatedly stressed two causes for low performance of irrigated agriculture in Pakistan, inadequate supplies in volumes and times, and the top-bottom hierarchy of irrigation management (Water Sector Investment Plan (1978), National Commission on Agriculture (1984), and the Revised Action Plan 1988). These studies recommended two main solutions for the improvement of irrigated agriculture:
 - a) supplies should follow crop demand patterns, and
 - b) the management should be made participatory with the involvement of users.
- The location of PHLC-USC system and the availability of Tarbela reservoir storage during low river flow periods made it possible to introduce demand- and crop-base irrigation supply systems in PHLC-USC systems.
- The availability of unutilized share of water to NWFP Province provides the opportunity to extend and remodel some of its irrigation systems. The Water Apportionment Accord of 1991 confirms the unutilized water. Because of this available share, a tendency of higher surface water allocation exists in NWFP, though the province has moderate temperature and better rains.

- The argument of two smaller provinces to receive full water allocated to their currently developed system regardless of any overall shortage is accepted by Indus River System Authority (IRSA), because this share is still less than their maximum allocation.
- Approach and involvement of ADB and international team of design consultants in the process from the beginning was mainly instrumental in planning, design and implementation of PHLC. This project is a perfect case of World Bank's concept of *involvement from the beginning*². The WAPDA and other national agencies have played almost ceremonial roles in decision making for planning, investigation, design and implementation.
- A strong justification for downstream control and pipe supplies is provided by not very successful experience of upstream control crop-based systems in NWFP. In addition to waterlogging and unsustainable level of high delta (water use) crops, appropriate management patterns could not be evolved. In these systems (CRBC, Lower Swat Canal) rotational schedules could not be established during low demand periods. Their operations have been "non-regime" with highly variable flows and massive operations in response to farmers demand (Habib 1998) causing sediment deposition and water logging. These problems played a role in accepting downstream control systems by irrigation engineers.

2.2 Steps of the modernization process: Who, what, how?

PHLC is a modern project by planning and design, expected to be the first in Pakistan with computerized operations, comprehensive monitoring and evaluation and involvement of users in managing irrigation supply. The role of International donors and consultants has been decisive at all levels of project implementation.

2.3 Project Planning, feasibility and investigation

Three organizations have been responsible for the formulation and implementation activities at the feasibility and inception stages: WAPDA, ADB and SWABI SCARP Consultants. While the fourth important actor, Provincial Irrigation Department has accepted the new approach. The seven activities planned and carried out by the Consultancy Agreement, between WAPDA and SSC present a comprehensive planning:

- Inception stage studies and documentation
- Pre-design investigations and surveys
- Beneficiaries dialogue
- Design procedures
- Tendering including pre-qualification, evaluation and contract awards
- Construction supervision & evaluation by donors
- O&M planning and commissioning.

² World Bank, 1981. Concepts for the future of irrigation planning.

Project Design and Construction

The design consultants proposed an infrastructure for Pehur Canal, which was new in Indus basin with a power tunnel, parabolic lined canal, downstream control gates and farmer's control supply at the farm level. Similarly, major changes were proposed for the remodelling of Upper Swat System. They clearly took a lead to define and control the design process in close collaboration with ADB. All of the investigation and studies proposed during design and bridging periods were accepted by WAPDA and PIDA. The same consultants are selected for the supervision of actual construction, which followed the proposed design.

Operational Phase

The full system is not operating yet. However, proposed procedures indicate continuity of the approach and the process. The PIDA has contracted International Water Management Institute to develop and implement "computerized operational procedures" for PHLC-USC system. The infrastructure provides scope for user's involvement and less physical control of PIDA.

2.4 Organizations/Institutions involved, including users participation

The number of National and International organizations involved in PHLCP are more than any canal project of Indus has witnessed so far. Not all are listed in the following:

- The Water and Power Development Authority (WAPDA). Many of its sub-organizations, Water Wing, SCAPR Monitoring Organization (SMO), Surface Hydrology Department,
- Provincial Irrigation Department, its design and Soil Conservation Wing
- Provincial Agriculture Department and its Directorate of Extension and On-Farm Water Management
- The provincial administration of NWFP
- Soil Survey of Pakistan
- The Provincial PE & DD, technically assisted by the consultants,
- Provincial Forest Department
- Social Development Unit of Public Works departments
- Planning, Environmental and Development Department (PE&DD)
- National Rural Support P (NARC), as an NGO proposed by PC-I
- PHLC Consultants, a Joint Venture comprising: Binnie & Partners (Overseas) Ltd; Hunting Technical Services Ltd; Lahmeyer International GmbH; National Development Consultants, Lahore; and BAK Consulting Engineers Peshawar.
- The consultants hired by different department, like the International Water Management Institute (IWMI).
- Groups of beneficiaries and people affected by the project. Apparently, interaction with communities is in the form of public agencies interaction with group of farmers.

A Project Directorate was established to implement irrigation and drainage components of the Project except sub-surface drainage. It is headed by WAPDA Chief Engineer as Project Director (PD) assisted by two full time Deputy Project Directors (DPD), one each from WAPDA and PID. The consultants are represented in the directorate.

Four main committees were formed consisting of the professionals from different organization, local and international consultants:

- For the overall guidance the Project Supervision and Coordination Committee (PSCC) headed by the Additional Chief Secretary (PE&DD) of GoNWFP,
- Project Coordination Committee (PCC) functioning under Secretary (DoI),
- Project Field Committee (PFC) headed by WAPDA CE
- Design Review Committee (DRC) for the Project under Chief Engineer (Development) of DoI

Many other task specific institutes are formed consisted of professionals from above mentioned organizations, for example Social Development Unit for 5 years. After completion of the projects tasks of these committees and working setups will be transferred to the permanent sections of three main organizations, WAPDA, Irrigation & Agriculture departments. Hence, only a part of the process could be institutionalized.

Some setups are quite unconventional, as obvious from this example:

A Farmer Dialogue Campaign is going on in Topi Priority Area (TPA) for the purpose of beneficiary participation in design of the proposed new irrigation and drainage system. This campaign, led by DoI with active assistance of Consultants, is being over-looked by the Committee headed by DC Swabi with representatives from DoI, WAPDA, Consultants and DoA (Position Paper 8).

Implementation of the modernization process

What has been implemented up till now could be briefly reviewed in the context of above-mentioned planning. The activities to be carried out by the consultants and the public sector are more successfully implemented.

Detail feasibility studies, discussion and documentation: The first feasibility study for an irrigation canal from Tarbela was carried out by WAPDA in 1975. A revised PC-1 was developed in 1979. It proposed an allowance of 0.6 l/sec/ha at the canal head. In March 1991, another PC-1 Proforma by WAPDA with updated costs and benefit analysis was proposed. ADB approved technical assistance (TA) for a new feasibility study by Swabi SCARP Consultants (SSC). The study was completed in June 1993 leading to the present Project and a new PC-1 proforma, which was approved by ADB on June 6, 1994 for funding (Loan No. 1294 PAK), which has been revised in 1997.

Investigation: ADB engaged the same consulting group, SSC to carry out additional investigation and studies during the “bridging period” of July 1993 - November 1994; some of them were:

- Study of Gandaf Tunnel, gate, stilling basin, hydrogeological parameters, cost estimates, etc.
- Analysis of rock samples taken from different depths from areas of main canal, Gandaf, Baja tunnels;
- Additional study of sandy soils on Maira Ridge and barren lands in Pehur Drainability Survey.
- About 10 topographical surveys of the command areas to produce contour maps for design purposes;

- Procurement and analysis of satellite imagery at a scale of 1:25,000, and upgrading of existing mapping.
- Geotechnical investigations at the sites of major structures in the Project area,
- Model testing of the existing stilling basin of Gandaf sub-tunnel to refine design and minimize risk of damage by cavitation.

2.4.1 Design

No problem was faced in the acceptance of proposed design, which was finally presented in a workshop for technical discussion.

2.5 Participation of beneficiaries

The PC-1 suggests participation of farmers at all levels through a “beneficiary dialogue, which was further emphasized by design consultants (Position Paper 3 1997); *“Design, implementation, operation and future maintenance of an irrigation scheme can present serious problems if adequate contact is not established between the beneficiaries and the implementing agencies. Unless the knowledge, understanding and concerns of the farmers affected by the scheme are taken into account, the scheme, or components of the schemes, may be rejected during the implementation or later during operation and maintenance....Therefore, the proposed coordination during the early stages of watercourse design would facilitate final adjustments in the main system design before commencement of construction.”*

As no NGO was available in the area an **administrative method** was adopted to contact farmers, *“These (meetings) were convened by the Assistant Commissioner Swabi in his office on 20, 21 and 25 of June 1995 in the presence of Committee members from Irrigation and Agriculture Departments, and the Consultants. During these meetings, the Consultants briefed the participants regarding the overall PHLCP procedures for the beneficiary dialogue and outlines of the proposed irrigation systems.”*

None of these groups has any knowledge or experience with the issues related to either buried pipe irrigation systems of crop based water management as proposed in TPA although farmers with tubewells have a good understanding of the trade-off between water application and crop yields. Further, the Consultants at present would be only involved in the supervision of construction of the main irrigation infrastructure in the TPA area.... It may also be that farmers accept the detailed design as a usual “top-down” process or express their concerns by intervening during the construction stage. However, by that time, the only choice available may be to implement the design as already proposed (position paper 13).

Farmer’s resentment in accepting conversion of watercourse into minors is acknowledged and three reasons are given to explain their behavior, **Chakbandi Splitting, Revising the Warabandi and New Watercourses**. The revised *warabandi* schedules give every farmer a longer turn with a smaller flow, which means more irrigation labour time and more cost for the farmers. New watercourses means that the existing watercourse will belong to PIDA, farmers will not be allowed to use water for animals, washing, etc. Additionally, farmers will have to give up land for the new watercourses.

The verbal feedback from the users and professionals indicates passive progress on the mobilization of community and farmer’s training. However, consistent efforts are made by the ADB and others to have successful participation of beneficiaries:

This work is to be handled by Agriculture Department under separately engaged consultants. The matter was, therefore, taken up by ADB Review Mission of December 1996 and the resultant decision is reflected in the following extract of the Aide Memoire: “8. *The commencement of this component is more than 18 month behind schedule..... A beneficiary participation campaign in Topi Priority Area (TPA) area was started in March 1995 and overseen by a committee headed by Assistant Commissioner, Swabi. The campaign participated by PIDA/WAPDA/DOFWM/Consultants was essentially completed by January 1996 including feedback for the detailed design of the main irrigation system in TPA (Position Paper 25).*”

2.6 Limitations of the stakeholders

Some of the limitations of the stakeholders are obvious during the planning and design phase.

- a. The organized representation of the civil society does not exist in the area. No community organization existed before the implementation of the project;
- b. The water users are all of a sudden asked to do many things, “understand their interest”, a new design” and then play a role. This process of their involvement is not “natural” and could not survive easily.
- c. Two public sector institutes are not very involved in the selection of design and operations of a system they are going to operate. Hence, a full ownership of consequences could not be expected from them.
- d. The major decision maker up till now, the Design Consultants are not responsible for the operation or performance of the system.

2.7 Actual modernization that took place

1. High water allocation for a hybrid system of crop- and demand-base irrigation supplies in a water stressed basin. Although this allocation is not based on a complete water balance or water account.
2. This is the first irrigation project, where Public Institutes have fully approved donor’s planning and design process and proposed design changes.
3. Comprehensive investigation of soil, hydrology, climatic and agriculture characteristics of the area. A wealth of data is collected about these characteristics.
4. Participatory Approach³: the interaction with users at early stages and efforts are carried out to somehow involve the users, mostly through civil administration for the “beneficiaries dialogue”.
5. The physical automation of the network consisted of numerous hydraulic components and control devices:
 - Gundaf Power Tunnel replacing previously envisaged gravity tunnel,
 - Parabolic and lined main canal: there were some doubts about the technical feasibility of a parabolic canal, but finally the proposed design is implemented.

³ The information campaign led by PIDA was to be organized to inform the residents and land owners in TPA about Project activities. The issue was taken up by the Consultants with PIDA during March 1995.

- Escapes in the primary and secondary system to manage excess water in the system and to increase responsiveness in case of rain.
- Downstream Level Control Gates in the main canals. A scepticism was shown by the local professional about the sustainability of these gates during design workshops. But, finally, AVIO & AVIS gates are accepted for the new and half of the remodelled system.
- Conversion of watercourses into minors. Partially implemented because of user's reluctance to accept it.
- Pipe Supply in Topi Priority Area through low pressure buried pipes with Harris valves: in the process of being implemented for 5% area.

2.8 Was any Training done prior, during or after modernization? What, how and for whom?

On-the-job training is provided to technical staff from WAPDA, Irrigation Department, local consulting firms and directly hired staff for the project by international consultants. The training areas cover computer applications, design, computerized drawing, construction supervision, record management, contract measurements, field and laboratory investigations and financial management. Project related training seminars, meetings and informal group discussions have been organized. Some middle level staff of WAPDA & PIDA received overseas training in Europe and Consultant's offices. The field staff will be trained for the actual operations.

Training is also provided to the staff of NARC and OFWM working to improve farmer's awareness. A pilot training program for farmers is implemented in the pilot area on the operations of pipe outlets.

2.9 Financing of the process

The first feasibility study and the PC-1 Proforma (A report in the format given by the Planning Commission of PAKISTAN containing an overview and justification of the project and detail cost of each component) of the project was funded by The Water and Power Development Authority (WAPDA) Pakistan during 1975 to 1979. The activity was a part of the Water Sector Plan and funds included a contribution from UNDP and WB. ADB funded a second Feasibility Study in 1992. Based on the findings of this Study, ADB approved a Loan (No. 1294 - PAK) for US\$ 127.6 million to fund about 80% of the cost of the Project. The remainder in local currency (Pak-Rupees 772 million = US\$ 25.7 million) is to be provided by the Government of North West Frontier Province.

The cost of the project increased substantially, due to new investigation studies, delay in construction and higher construction cost. The local component was affected by devaluation of the local currency. Some of the costs are summarized below:

2.10 Estimated cost of the process: Total, per unit area

Estimated Cost (September 1993)	(US \$ Million)	(Rs. Million)
Asian Development Bank (Loan 1294-Pak)	127.6	3,828
Government of NWFP	25.7	772
Total	153.3	4,600
Estimated 1997 (Split is not available)	179.5	6,763
Percentage Increase	12%	47%
	US\$	Pak Rupees
Cost per hectare of total directly benefited area	3766	152005
Cost per hectare of new Irrigated area ¹	20252	817381
Cost per hectare of new cultivated area ²	9984	402969
Actual Cost at the end of 2002	Not Available, an increase of 10 to 20 percent expected	

Notes/ All of the command area of Pehur canal + expected new irrigation on Upper Swat System (7%)

Difference of the area cultivated in 1995 and projected with project (120% of Pehur CCA+ 26% of Upper Swat CCA)

2.11 Performance evaluation prior to modernization?

An economic cost benefit analysis was carried out as a part of the feasibility study in 1994. It has been revised in 1997, based on M&E survey. The revised PC-1 ⁴(R2) gives estimated benefits in irrigated area and yield. It expects socio-economic uplift, better conditions of marginal groups and women and employment generated by the project. A quantitative performance evaluation was not carried out other than for the Irrigated area, and cropping intensities. Following benefits are expected by the PC-1 (R2).

1. New irrigation in rain-fed area, which will increase cropping Intensities from 27% to 150%.
2. Increase water allowance of the existing system, which will increase cropping intensity from 130% to 157% and yields by 10% (for wheat) and 50% (for sugarcane).
3. Benefits due to drainage to Swabi area (a separate sub-component).

PC-1 also expects:

- Incremental agricultural benefits, resulting from better water management due to automation, are estimated at Rs. 32 million annually (one Million US \$), and power loss saving Rs. 8.4 million annually (0.25 M US\$).
- Additional drainage and irrigation areas will be included
- Accelerated build-up of agricultural benefits because of Participatory Irrigation Management
- The total economic value of annual incremental crop production at current farm-gate prices at full development is estimated at Rs. 1,364 million (US\$ 33.8 million).

⁴ Planning Commission's Proforma to submit a project for approval.

Existing growth rate: two surveys conducted in 1988 and 1994 shows a good growth rate in Upper Swat Command without project.

	SAR (1988)		Baseline (1994)	
	Poor ^{2/}	Good ^{3/}	Domain I ^{4/}	Domain II ^{5/}
Wheat mt/ha	1.21	1.51	2.15	2.19
Maize mt/ha	1.16	1.83	1.88	1.88
Sugar cane mt/ha	24.7	40.0	28.8	41.8
Cropping intensity %	100	125	135	144

Table: Comparison of ADB Staff Appraisal Report 1988 and Baseline Yield and Cropping Intensity Estimates

2/ Tail areas with waterlogging and water shortage problems

3/ Head areas with few problems

4/ Areas with drainage problems, many also water-short

5/ Areas without drainage problems, generally also with good irrigation supply

According to the proposed M&E another survey will be carried out before the full operations of the system.

3 PART C. IMPACT OF MODERNIZATION

The new system is yet not operational, but some changes are visible during the process.

Governance⁵

- A visible change during project implementation is the establishment of many committees and working groups to look after different tasks. Most of these are formed based on the recommendations of international consultants and have consultants as their members. Their performance has been evaluated satisfactory by ADB. Reporting has been a strong aspect of the whole process. Some of these committees and procedures are expected to be continued, especially those concerned with operations, monitoring and evaluation.
- The role of local Institutions and hence the sustainability of the procedures is not very visible at this stage.
- A lacking aspect has been a willing and effective involvement of water users, as mentioned above under the heading of “modernization process”, which is expected to be improved as a result of the creation of water users organizations.

3.1 Water rights, water allocation:

The terminology, “water rights” is not used in the PC-1 or in the feasibility studies, hence logically water allocation and operational procedures “fixes these rights”. In supply based irrigation systems of the Indus basin, authorized quantity of irrigation water a farm could draw, is defined by *seasonal water allocation* of the area and **10-daily volumes of water** to main canals scheduled at the Provincial level for water regulation. The allocations are uniform over the

⁵ Much could not be said about the Governance of the PHLC during the operational phase, the comments are only related to the present phase.

season. Design capacity of the system is 20% higher than the kharif allocations. While 10-daily volumes, approved by the regulation authority are influenced by the historical flow hydrograph at the diversion node and other long-term constraints. The modernization has influenced both of these factors.

The first point of departure for the remodeled and new areas is higher basic allocation of 0.63 l/sec/ha and 0.70 l/sec/ha at watercourse head, as compared to 0.37 l/sec/ha in the old system.

- The second point of departure is physical flexibility, which is 100% for Topi Area and about 40% for rest of the system (Design Report 1997).
- The third point of departure is 10-daily approved allocations, which are to meet full water requirements of 170% cropping intensities, about double of the average of the Indus basin.
- A complete new concept of water rights would be experienced by the demand based Topi Priority area, allowing users to draw whatever water they want up to double of their basic allocation and practice only day-irrigation.

3.2 Water service provider

The water service provider is ultimately the Provincial Irrigation Development Authority (PIDA) at users' interface, same as for other systems of the basin. PIDA is also responsible for the maintenance of main and secondary canals to ensure water supply. WAPDA is involved for the diversion from Tarbela through Gundaf tunnel.

However, the managerial function of PIDA would be different. For day to day real time supply management in the auto-control part of the Topi priority area, users would have full control on water acquisition. Their decisions to acquire water will be fully responded by the conveyance and diversion system up to the reservoir. For the rest of the system, users will have higher influence on the actual uses.

3.3 Water distribution method

The expected distribution method based on both operational practices and the opinion of the Chief Engineer PHLC will be:

- Continuous Supply in the system up to farmers outlets, about 65 percent of time.
- *The traditional* method exists at farm level, coupled with rotation among the secondary canals during low demand period. The watercourse *WARABANDI* is a seven day roaster during which each user (farm in fact) has a time allocation based on his farm size; during this period he is entitled to the entire water diverted to the watercourse. Currently, in the remodeled Upper Swat system the practice of rotation is not regular and secondary canals are mostly operated at variable flows. It could not be confirmed, but, according to the Chief Engineer it is more regular at the watercourse level.
- About 5% of the total command, in the Topi Priority Area, will get supply on users' demand through pipe outlets controlled from the downstream. These pipes are just like household supply of water, controlled by Harris valves, which farmers would be able to open and close whenever they want. Practically, extraction by the user's could be different from the crop demand.

3.4 Water service fee structure

No change from the existing setup is planned in the near future (Chief Engineer PHLC). Hence, water service fee will depend upon cropped area and the type of crop grown. Per hectare rates vary from 3 \$/ha for fodder crops to 10 \$/ha for orchards.

3.5 System performance

The real impact on performance due to modernisation could not be judged at this stage.

3.6 Have other systems in the country followed the same process?

No other system in the country has followed the process. However, crop based and high water allocation approach was already implemented in NWFP without automation. The low performance of these systems, especially excessive use of water provides justification for the automation.

4 PART D. CONSULTANT'S OWN CONCLUSIONS AND OR COMMENTS, SUGGESTIONS OR RECOMMENDATIONS

4.1 What is your appreciation of the modernization process that took place?

The process of modernization adopted for PHLC has followed most of the procedures recommended by WB and ADB. The documents produced during the process reflect comprehensive approaches, involvement of stakeholders and new policy issues. ADB followed WB's policy for irrigation planning (1981), "*the Bank would have preferred to become involved at an early stage in practice, its role was in examining projects and deciding if they were suitable for financing without being able to develop lending based on a set of technical, regional or other criteria.*"⁶ The second feasibility study by ADB, selection of consultants and their TOR, detail technical studies, surveys and the design approaches of intensive agriculture and automation, are parts of this policy. In case of physical changes, engineers of WAPDA, PIDA and other organizations have accepted all components of the process. An important change is acceptance of demand-based and downstream control systems by the Public Sector Institutes. The project has made special and consistent efforts to involve and convince communities, apparently with not very positive output. The modernization of the actual operations is planned through computerised operations and the continuity of M&E procedures.

4.2 Do you perceive any major gaps in the process that took place?

Based on an overview of the process so far and discussion with consultants and local agencies, some of the gaps/ apprehensions could be summarized as:

The water allocations to the system are exclusively from river water, groundwater is not included as a resource, the contribution of rain is not explicitly considered and the cropping intensities are kept too high (175%)⁷. Currently, groundwater is used in the rain-fed areas and apparently cropping intensities are quite good. Hence, like other two crop-based systems of NWFP (Lower Swat & CRBC) more surface water is allocated to the command area than required by

⁶ World Bank. 1981. Concepts for the Future in Irrigation Planning.

⁷ When systems are planned utilizing only river water, cropping intensities are kept low, while much higher cropping intensities could be achieved through groundwater use and rain contribution. The Upper Swat system itself is designed for 80% and has achieved 145% cropping intensities. A design for the full potential of the system must be based on a proper water balance and accounting of all water components.

crops. An excessive use of water by farmers and a substantial percentage of “surplus water” could be expected. This will increase the drainage effluent and make the productivity of water low. Therefore the system is not water efficient by design (planning).

High surface water allocations, and very high physical flexibility (50% to 100% higher than peak requirements) has made the system too cumbersome. Management of water distribution and evaluation of operational targets like equity and efficiency will be difficult. The physical system will be supportive of non-optimal practices of farmers. *It may not allow to test expected improvements through water saving due to excesses in water supply.*

PHLC is an exceptionally expensive system for the basin. Sizes are one of the factors making the system economically expensive. Some other factors like devaluation of the local currency, extra cost of physical components like power tunnel at the head would have been considered in feasibility scenarios and thoroughly discussed. To some extent, it is a “foreign system” because of consultants’ driving role, which will continue till the planning of *computerised operations*. Up till now farmers are more resistant to the “modernization” process than the public sector. It seems difficult that the present phase will smoothly lead to a “better managed and operated system”.

The institutional and socio-economic components are less clear in conceptualization, planning, interpretation and implementation than the physical component.

The crop-based systems in Pakistan has adopted a philosophy of excessive supplies like an anti-thesis of supply based systems. Apparently “scarcity by design” is replaced with “abundance by design”. The agriculture performance may be higher in the beginning but sustainability of water and land resources is at high risk. Systems are too expensive (not only due to modernization), nobody is happy and expensive water is wasted. Logically, there is no link between modernization and excess water supply, the first is based on scientific techniques and rational procedures, while the second is based on specific policy or construction decisions. Unfortunately, an apparent link between modernization and more water hides the real issue of Indus basin, to use modernization for the better performance of water scarce systems.

4.3 Can the process be replicated elsewhere?

The current process has not much scope to be replicated, because, a) new perennial systems are not planned, b) only NWFP has water for further perennial irrigation development. However, some components of the process could be replicated or learned from, by projects to be remodeled. For example farmer’s water use practices in an excess water supply system, where water refusal is possible. The PHLC, probably provides appropriate scenarios to better understand issues related to participatory irrigation management.

4.4 What lessons can be learned from the modernization process that took place?

It is early to draw lessons on the final performance and operation of the PHLC canal network. Based on the current available information, some preliminary lessons could be put forward:

The “comprehensive planning” could be interpreted in many different ways. For irrigation design and management, there is still need to comparatively analyse required targets (an old term which should not be forgotten), as well as procedures and priorities from the planning to the implementation stage. For example, “proper water accounting” could be a useful tool not only to address water stress but also water conservation.

Irrigation is one of the sectors criticised for expensive infrastructure development during recent decades. The PHLC experience shows that the path adopted by donors is the main reason for expensiveness. The gap between an international level of development/construction scheme and local benefits is an important factor of financial inefficiency.

The modernization could have trade offs, which could be adjusted against the flexibilities in the light of priorities. May be its time for the irrigation sector to have a comprehensive document on irrigation systems' design, remodelling and sustainability.

In-depth Study: The PHLC is a well-documented and surveyed system. It provides good scope to study above- mentioned generic issues, after its operational phase is commenced.

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