A review of planning strategies of salinity control and reclamation projects in Pakistan

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1 Background and extent of the problem

1.1 Background

The problem of waterlogging and salinity in Pakistan is typical for irrigated agriculture where adequate drainage is not provided. The causes are fairly well known and well documented. These causes shall be only briefly stated.

In the latter half of the 19th century, the British undertook the construction of weir controlled irrigation systems in the Indus plain. Soon after the commissioning of these canals the groundwater table started to rise steadily. A substantial contribution to the watertable build-up was seepage from canals and watercourses. Deep percolation losses from irrigation also contributed to the problem. Development of road and railway networks without proper cross drainage facilities along with the construction of flood and irrigation bunds compounded the problem by obstructing the natural drainage. Heavy monsoon rains resulted in ponding of the depressions, thus increasing the volume of water percolating to the groundwater.

Soil salinity in Pakistan is a product of climatic conditions, original soil chemistry, land use, irrigation practices, and the shallow depth of the watertable.

1.2 Extent of the problem

The Indus Plain covers a gross culturable command area of 36.5 million acres. Out of this 32.6 million acres are irrigated (including both perennial an non-perennial areas). The irrigation system in the Indus Plain encompasses two large storage reservoirs, 17 barrages, 8 link canals, and 40 000 miles of irrigation conveyance systems. Before the construction of this network, the watertable in the center of the doabs (the land strips between two rivers) ranged between 75 and 100 feet. The seepage from the unlined irrigation channels and on-farm percolation losses combined with the blockage of natural drainage resulted in a rise of the watertable at a rate of 0.5 ft to more than 2 ft per year depending upon the hydrogeological features of the specific areas. This trend is shown in Figure 1. Before anything could be done on a proper scale, the watertable had risen to within a few feet from the ground surface. This was the start of the occurrence of salinity and waterlogging problems.

The first large scale studies were undertaken in 1953 under the Colombo Plan. The results of the photographic survey were available in 1958. Seventeen per cent of the

area was mapped as waterlogged (predominantly poorly drained), seven per cent was predominantly severely saline while an additional sixteen per cent had saline patches. Due to difference of opinion on the definition of 'waterlogged and salinized land' different figures are available in different reports. There was, however, no difference of opinion that the situation was alarming and it was generally believed that Pakistan was loosing in the Indus Plain 100 000 acres of cultivated land each year. The government took serious note of this and published the problem as 'Pakistan's Enemy No. 1'. The newly created 'Pakistan Water and Power Development Authority' (WAPDA) was made responsible for fighting the twin menace of salinity and high watertable conditions.

2 Planning concepts

2.1 Early planning strategies

The problem first appeared in the Punjab (central part of Pakistan) and the provincial government at that time established a 'Drainage Board' as early as 1917. The first large scale anti-waterlogging measures were undertaken in 1933, which comprised construction of seepage-cum-surface drains in the affected areas. By 1947, 2270 miles

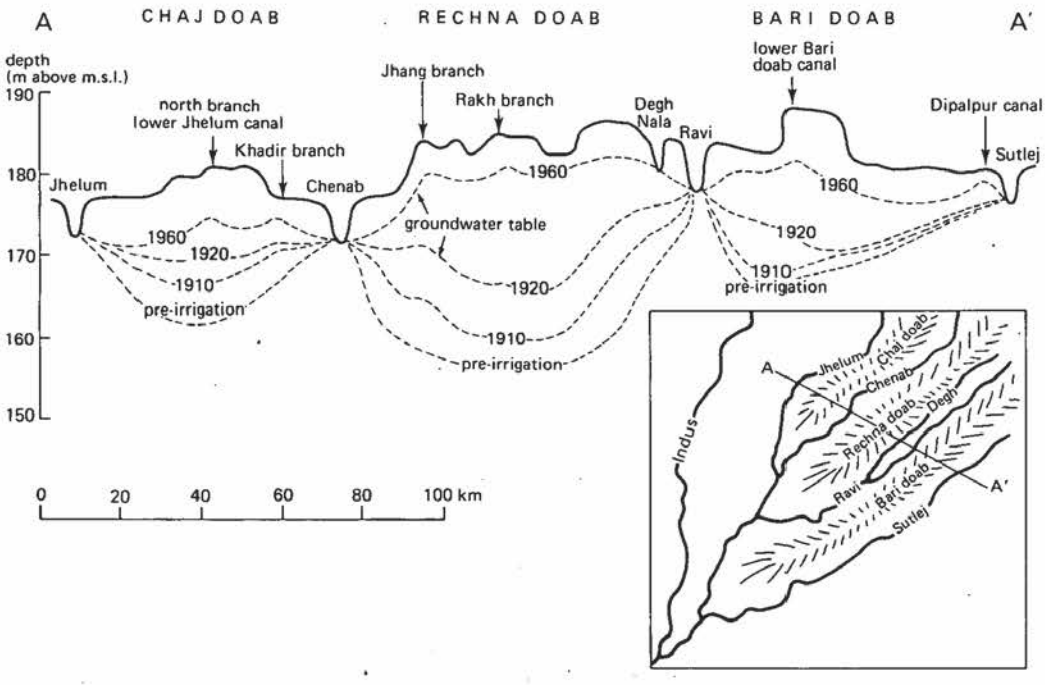


Figure 1 Groundwater table profiles in Punjab (Northeast Pakistan)

of such drains had been constructed. Due to flat topography, improper design, and inadequate provision of lateral tributary drains, the system did not work well as it could not arrest the rise of the watertable. Consequently the interest in the extension of the surface drainage systems started to decline.

Lining of canals as a preventive measure was first attempted in 1943 and a few canals including two of the link canals under the 'Indus Basin Replacement Works Programme' were lined with a double layer of brick lining. The cost was so prohibitive that a further lining programme could not progress. The first small scale subsurface drainage project was initiated around 1940. Tubewells were planned as a means for intercepting the canal seepage. A total of 1257 tubewells were installed first at a distance of 60 ft from the canal and thereafter at 600 ft. This could provide relief in a small strip of land along the canals but obviously could not solve the problem in areas further away from the channels.

Experts of United Nations visited Pakistan in 1950 and recognizing the usefulness of tubewells as a drainage measure recommended a few tubewell drainage pilot projects. As a consequence, 202 tubewells were installed in the Rechna Doab (1965-60).

Other measures that were planned but for various reasons could not be implemented on a large scale, included:

a. Preventive measures
   - Frequent and extensive canal closures;
   - Lowering of canal water levels;
   - Conversion of areas from perennial to non-perennial irrigation.

b. Curative measures
   - Reclamation through rice cultivation;
   - Tree plantation.

While conceptually most of these measures offered solutions, none was applied either extensively or intensively. The onslaught was at such a scale that stepping up of the efforts was sought with international assistance. In the meantime the wet cycle during the 50's further aggravated the problem of waterlogging.

2.2 Planning strategies developed by WAPDA and its consultants

To fulfil its obligation, WAPDA put in gigantic efforts at international level for detailed investigations. In addition to the World Bank Study Group, a large number of foreign consulting firms was involved in the study and planning of projects.

While the detailed investigations in other parts of the Indus Plain were still in progress, the first Salinity Control and Reclamation Project (SCARP-I) was planned for implementation. Under this project 2041 tubewells were put into operation progressively by March 1963. The project covered an area of 1.2 million acres.

The adopted development approach primarily constituted subsurface drainage by installing tubewells wherever feasible and utilizing their effluent to supplement irrigation water supplies directly or by mixing with canal water. In addition, the surface drainage system was also be enlarged to deal with surface run-off. Soil reclamation was envisaged to the extent attained through drainage provided under these projects.

Further reclamation efforts were suggested to be undertaken by the farmers themselves.

The overall approach, planning concept, and design criteria developed by various experts and consultants had only minor differences. Tipton & Kalmbach (USA) inclu-

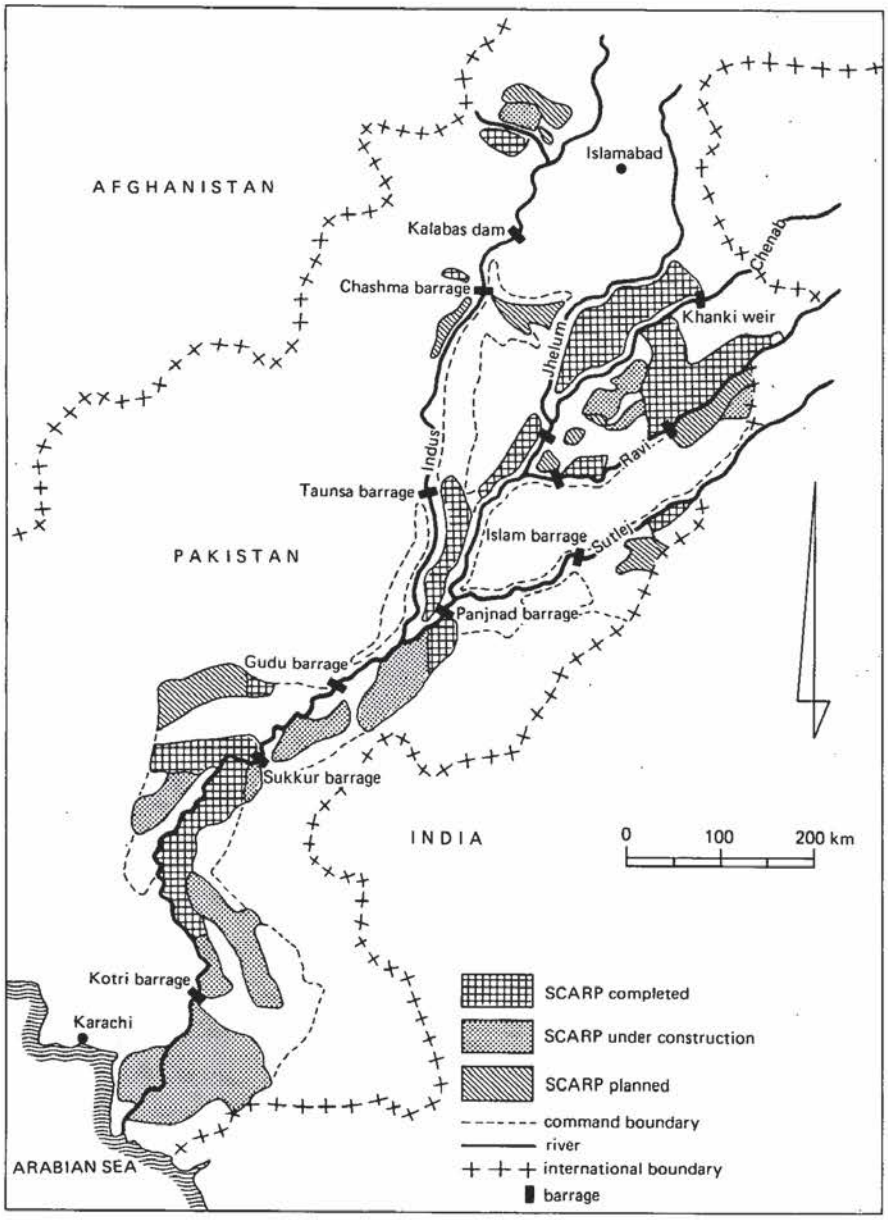


Figure 2 Completed, under construction, and planned reclamation projects in Pakistan

ded a design criterion that required recovering the entire recharge of 20 MAF (Million Acre Feet) plus an additional mining of 20 MAF per annum so that the watertable is deflated to 70-100 ft below ground level i.e. the pre-irrigation level. It was stipulated that initially one MAF of highly saline water would be exported to the sea.

The World Bank Plan on the other hand suggested a balanced pumping to stabilize the watertable at 10 to 15 ft from the ground surface. This plan was adopted and thereafter a large number of projects have been completed up to June 1985. Figure 2 shows the completed, the on-going, and the planned projects.

3 Achievements and shortcomings of completed projects

By June 1985 WAPDA had completed 32 reclamation projects covering a gross area of 8.77 million acres. This included the construction of 12819 tubewells and 2131 miles of surface drains at a total cost of Rs. 4955.00 million.

The projects in execution include 15 reclamation projects covering a gross area of 6.99 million acres, involving construction of 3841 tubewells and 8979 miles of drains of which 4669 miles of tile drains. The total estimated cost of these schemes is Rs. 10215.00 million.

There can be no doubt that the SCARP-projects have provided some relief to the affected lands but it is also generally agreed that the objectives were only partially achieved. The SCARPs also had a great impact through their demonstrative effect. This is evidenced by the construction of private tubewells which number increased from a few thousands at the start of the programme to over 200 000 by June 1985. The small capacity private tubewells in SCARP areas greatly helped in reducing the waterlogging and salinity conditions. Cropping intensities also increased but there are many other factors involved and the exclusive contribution of the SCARPs has not yet been evaluated.

After 30 years of struggle, and with billions of Rupees invested, Pakistan is still far away from solving the problem. Table 1 shows that the groundwater table is still rising towards the surface.

Table 1 Watertable depth in the Indus Plain of Pakistan

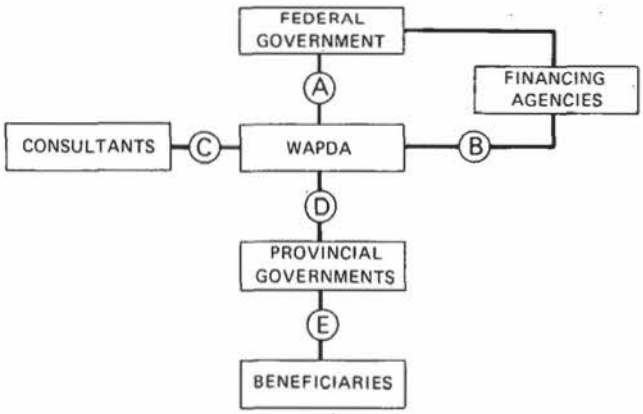
Survey period	Total area	Very poorly drained (0-3 ft)	Poorly drained (3-6 ft)	Moderately drained (6-10 ft)	Well drained (> 10 ft)	Misc. type
1953-75*:						
in million acres	24.75	0.58	2.64	5.66	15.24	0.63
in per cent	100	2	11	23	62	2
1977-79**:						
in million acres	41.28	27.40	6.28	8.27	22.94	1.05
in percent	100	7	15	20	55	3

* Previous surveys

** Based on WAPDA's latest survey of 41 million acres of irrigated area

4 Evaluation of the completed SCARPs

To understand what went wrong, the management set-up and communication links between the various agencies involved in planning, designing, financing, implementing, and maintaining of the projects need to be known. This is shown in the following diagram:



The various agencies involved are elaborated hereunder.

WAPDA

WAPDA is the executing agency responsible for identifying, investigating, planning, designing, constructing, and then handing over the completed projects to the provincial governments after an initial operation of one year.

Federal government

The federal government approves and finances the project either directly or in case of large projects, jointly with international financing donor agencies.

Consultants

As a condition for the effectiveness of the loan and also as dictated by the nature of a project, WAPDA is required to engage consulting firms which in the past have mostly been foreign firms.

Provincial governments

Provincial governments are responsible for operation and maintenance of the projects and for collecting water fee rates from the farmers. The revenue receipts in excess of the operation and maintenance costs are to be used for repayment of the loan.

The role of the above agencies has been questioned in many respects. Particularly in planning deficiencies, time limits, efficiency in getting the work completed, and lack of operational and maintenance skill.

Coordination with federal government (Link A)
The major problem between WAPDA and the federal government has been the inadequate funding, resulting in delayed completion of the projects. The project appraisal and feasibility studies were generally biased in favour of higher benefit-cost ratios, with the result that there was a large gap in the estimated and actual costs. Apart from upsetting the cost effectiveness of the project, it also involved additional time consuming procedures in getting the revised cost estimates sanctioned by the government.

Role of financing agencies (Link B)
Link B is generally problem free apart from the cases where co-financing is involved and more than one agency provides financial means for a single project. There are serious coordination problems, lack of understanding and lengthy channels to arrive at decisions in planning and designing stages of the project. Elaborate procurement guidelines and rigorous procedures of some of the financing agencies also tend to delay the project.

Role of consultants (Link C)
Link C relates to the basic work of planning and designing the projects by the consultants either independently or jointly with WAPDA. In the context of the completed projects the following serious deficiencies can be stipulated:

- Some of the assumptions and design criteria adopted by these firms eventually proved to be highly idealized. A specific reference is drawn to the design of the earlier SCARPs where the optimism in planning concept was that low quality water was fit for application either directly or after mixing with canal water. Water of 1500 to 4000 ppm was expected to be mixed with canal supplies. It was too ambitious to achieve it in practice as the farmers had little knowledge and background on how to mix water. It was wrong to apply the law of averages for determining mixing ratios;
- Although each tubewell is a discrete project, proper attention was not given to individual tubewell siting and design. The concept of aggregation and group design did not work;
- Reliance on expensive imported equipment eroded the cost effectiveness of the project;
- The foreign consultants concentrated on the scientific and engineering solutions of the problem and did not take into account the cultural and socio-economic bias of various farming communities. Their planning also did not have any relationship with the management capabilities of the beneficiaries;
- There was a lack of emphasis on preventive measures such as the rehabilitation of surface drainage and irrigation systems and the improvement of on-farm water management practices;
- There was no significant local participation in planning, designing and implementing the earlier projects;
- The consultants usually worked strictly within the 'terms of reference' and did not always produce the best engineering solution of the problem. In certain cases the

employer's biased approach to a particular solution also influenced the work of the consultants;
- Design of large capacity tubewells without considering the existing carrying capacities of the watercourses created operational, maintenance, and distribution problems;
- Mild steel pipes and strainers were designed and used despite the corrosive nature of the water in the aquifer;
- The planning concepts were immune to evaluation or to criticism as no significant provision for monitoring and evaluation was made as part of the project plan;
- Possibilities of salt water intrusion from the lower aquifers were not taken into account;
- Surface drains being the backbone of any drainage system were not given the proper attention.

Implementation deficiencies

In the implementation stage the typical problems experienced were delays and excess spending. The element of delay was not so much due to organizational inefficiencies but due to inadequate funding. Some of the project preparatory work could have been concurrently started while the project was appraised.

The excess spending was on account of (a) the initial estimate being unrealistic with a view to get the project approved and (b) the reliance on high technology particularly for the tubewells.

Operation and maintenance problems

By far the most serious problems have been experienced in the operation and maintenance of the tubewells as well as the surface drains. The expertise of the provincial departments has not yet developed to the level of appreciating the implication of continued operation of these tubewells. As some of these tubewells started pumping brackish water the farmers became dissatisfied and took the programme as a curse. A number of tubewells had to be abandoned on this account.

The trade unionism of the tubewell operation staff was one of the major hurdles for the maintenance agency to have effective control on the utilization of these tubewells. The operators usually absconded from their duties leaving operations in the hands of farmers or their workers who played with the sophisticated starting mechanism causing a number of mechanical and electrical breakdowns. The deep well axial-flow pumps could only be repaired in the departmental workshops and the spare parts were not readily available.

Excessive billing for energy consumption also increased operation and maintenance costs.

5 Current planning concepts

In view of the lessons learnt from the completed projects, the on-going accelerated plan for waterlogging and salinity control has been revised. The new approach equally

emphasises on preventive and curative measures. In first instance every effort will be made to prevent occurrence of waterlogging and salinity. But wherever it cannot be controlled by preventive measures, appropriate curative methods will be adopted.

Preventive strategies
- Effective on-farm water management to reduce losses in the irrigation system;
- Tree planting along irrigation channels;
- Lining of minor irrigation channels;
- Launching of irrigation and drainage system rehabilitation projects;
- Extension of field drains by the provincial agricultural departments and maintenance through water users associations;
- Public tubewells in the fresh groundwater zone shall be transferred to the private sector;
- Once a reclamation project has been implemented then the provincial governments should not increase the water supply in that area without the permission of the federal government.

Curative strategies
- Priority would be given to the reclamation of disastrous areas underlain by saline groundwater depending upon the productivity potential of land, types of crops grown, and density of population, etc;
- Reclamation of areas underlain by fresh groundwater should be the responsibility of the private sector, with the exception of those areas which cannot be reclaimed by vertical drainage. The government shall provide a closely spaced electrical grid, an advance loan and subsidies to encourage installation of tubewells;
- Research institutes and farming associations shall be closely associated in developing site specific solutions to the drainage problem;
- Tile drains shall be installed where the aquifer is not suitable for tubewells or where the groundwater is highly saline.

A Four Year Reclamation Plan (1986-90) has been prepared on the basis of the new approach for a total financial outlay of Rs. 15 000 million to reclaim 4.5 million acres.

6 Subsurface pipe drain versus tubewells

The physical properties of the aquifer throughout the Indus Plain are suitable for either method of drainage except in some areas where the aquifer conditions are not suitable for tubewells. There are a number of factors that need to be considered in selecting one method or the other.

General dissatisfaction with the performance of the tubewells, particularly the deterioration of water quality by salt water intrusion in saline areas has tended to swing the balance in favour of subsurface pipe drains. The problems relating to operation and maintenance of tubewells have already been enumerated. The pipe drains on the other hand offer the prospect of relatively trouble free maintenance.

The tubewell provides a temporary relief and a few years of continuous wet spell

could reverse the declining watertable trend. This has already been experienced during the heavy monsoon rains of the early 70's.

At present three tile drainage projects are under construction in Pakistan. It will take a long time before these are monitored and evaluated for their effectiveness and operational performance. However a major constraint in pipe drainage is the relatively high initial capital investment. A study was carried out by ILACO for SCARP-VI to determine the cost effectiveness of the two alternatives. They found that on the basis of average annual cost, the two alternatives were equally cost effective.

The effluent from the tubewell has generally a higher mineral content and involves a large quantity of water for disposal. For pipe drains this quantity is limited and is only present when the watertable is high.

At present both methods are being considered and are being adopted according to the physical properties of the respective project areas.

7 Conclusions and recommendations

The foregoing review of the waterlogging and salinity problems shows that while a number of corrective actions has been taken in the field of project planning, there are still a number of issues that need to be tackled seriously for effectively dealing with the problem at national level:

- Surface drainage, particularly the extension of field drains to the farm level has still not attracted the attention of the planners. The existing overall length of the drains is approximately one third of the irrigation conveyance system. The length of the drainage system should preferably match the length of the irrigation canal system;
- Maintenance of the surface drains is far from satisfactory due to the problem of a flat gradient resulting in low velocities and sedimentation. Methods of controlling erosion on the side slopes and sloughing problems are the most serious maintenance constraints that need immediate attention;
- In the interest of efficiency, there is a need to streamline and to simplify the procurement procedures of the financing agencies. It is also desirable that co-financing has to be avoided as much as possible;
- There is a need to explore the possibility of making the organization responsible for implementation also responsible for operation and maintenance;
- Farmers associations should be actively involved not only in the identification of the project but also during the planning and implementation stages;
- Measures should be taken to check the untreated city sewage and industrial waste entering the surface drains. For this purpose a legislative act may be necessary;
- With a view to reduce the cost of subsurface pipe drainage a research programme needs to be undertaken to study the most economical system, including envelope material, pipe size, pipe depth, and method of installation;
- All projects should be backed up with research to develop low cost technology suited to Pakistani conditions. The recently established International Waterlogging and Salinity Research Institute should be involved to play its role in a most meaningful way.

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