by the farmers such as the construction and maintenance of link watercourses, bifurcation, trifurcation, mixing chambers where saline water from the tubewells can be mixed with fresh water from the canal and rehabilitation/ re-alignment of the watercourses(farmer's ditches).

5) Close monitoring of the effect of closed re-cycling of tubewell water to eliminate chances of future re-salinization which is currently taking place at a very large scale.

6) To improve the operating efficiency of the project facilities which will in turn improve the financial and economic return on the investment.

All these issues have been under the active consideration of the government and a number of alternative approaches have been evaluated. Some of these are:

a) Status-quo

b) All the project deficiencies should be made good by the Government and the projects handed over to a public/ private limited corporation on mutually agreed terms and conditions. For the overall control and policy formation, this corporation should have a board of directors both from the beneficiaries and public functionaries in the ratio of 50:50. The chairman of this board should be by rotation from the two sides for a period of one year.

c) After renovation of the project, it should be handed over to an autonomous Land and Water Development Board which should be manned by renowned experts and professionals hand-picked from various disciplines to run these projects on the most scientific lines as the area development projects. The members of the development board could be from the departments concerned as well as the public representatives from the concerned area.

d) Individual tubewells sold and handed over to the owners of the lands adjoining the tubewells individually or collectively to a farmers' association/cooperative.

e) Project tubewells divided into manageable small lots and transferred to local private enterprises for their day to day operation and management.

The pros and cons of all these alternatives are under investigation but a final decision is yet to be taken. Whatever institutional

arrangement is made, the objective remains unchanged. The operating efficiency of the project facilities is very low. It has to be improved tremendously. The standard of operation and maintenance must be upgraded and farmers must be persuaded, trained and motivated to step out of their traditional practices to adopt better farming practices. This involves a completely new concept for the Indus Basin - a multidisciplinary concept rather than purely engineering or agricultural concept applied in isolation of each other. The team of public functionaries has to include water engineers, planners, mechanical engineers, agriculture scientists, agronomists and social scientists. The existing field extension services have also to be revitalized to fuse new spirit and inject new disciplines into it. The basis of managing the project should not be a routine matter as has been in the past but it should be productivity oriented. Nothing can be achieved, however, without full scale public participation and motivation of the farming community. The educated village elders and retired public functionaries residing in the villages should be enrolled to form task forces to motivate and stimulate changes in rural setting to make it more conducive to rapid agricultural development. A number of thoughts on these matters are included in a report submitted to the President of Pakistan during July 1978 by a committee of engineers constituted by the Pakistan Engineering Congress which included the author as one of its members.

Evolution of Revised Strategy

As stated earlier, during the later part of Third Five Year Plan and the first few years of the Fourth Five Yar Plan, developmental efforts in the country were almost at a standstill. Resources were hardly available for discharging the committed liabilities rather than taking up of any new programmes. This provided an opportunity to re-assess the situation in the light of the country's potentials and problems. In this process, the whole gamut of conceptual, technical, financial, managerial, administrative and socio-economic aspects of reclamation and drainage projects were thoroughly reviewed both by the provincial as well as federal

government. A number of high powered committees were constitutued both at the provincial and federal level for this purpose. It was, however, simultaneously realized that further delay in taking effective measures would be seriously deterimental to the agriculture economy of the country. Reviewing the overall strategy, the then President of Pakistan made the following observations on March 6,1973:

> "Next year we have to give greater attention to the curse of waterlogging and salinity. So far we have toyed with the problem. The seriousness must be seriously faced. We must do something whorthwile on a large scale, far above the SCARP scale"(1973).

Accordingly, the Planning Commission was directed to formulate proposals for an accelerated programme of waterlogging and salinity control in Pakistan on a priority basis. In order to avoid the shortfalls inherent in the previous project designs, a committee of experts including the author was constituted by the Government of Pakistan to evolve technical criteria for the accelerated reclamation programme. This committee comprised representatives of Planning Commission, Federal Ministry of Water and Power, all the provincial governments and WAPDA. Following design criteria were adopted by this committee during its meeting on May 17,1973:

1. The level to which the ground water should be lowered should be 10-15 feet. Minining of ground water was not recommended.
2. Capacity of tubewells in fresh water zones should be one to two cusecs and in saline zones 1.5 to 2.5 cusecs.The capacity in the saline zones, however, need not be rigid (if the tubewells are meant for drainage alone) but should be decided on merit of each case.
3. Fibre glass and stainless steel were not recommended as these were expensive, and brass and coir rope were considered as most suitable material for strainers. PVC and other types could also be considered for experimental purpose.
4. Instead of deep turbine pumps, centrifugal pumps could now be used as water table is to be fixed at 10-15 feet and no mining is to be done.
5. For water qualities, US Department of Agriculture Handbook 60 standards should be adopted.

Most of the above recommendations were finally approved and issued as guidelines for future planning of these projects. The question of strainers was, however, kept open for collecting more information before a final decision was taken. It was,however, conceded in principle that maximum emphasis will be laid on the use of local materials and technical know-how. The practical manifestation of this decision has appeared in the form of consulting engineering firms created in the public sector for planning, designing and implementation of various development projects both within Pakistan as well as abroad.

New Planning and Management Efforts

To implement the new plicy options, following actions were taken:

a) Creation of consulting engineers and other firms in public sector for investigation, planning, designing and implementation of public sector development projects. These are:

   i) National Engineering Services(Pakistan)Ltd.

   ii) National Construction Co. (Pakistan) Ltd.

   iii) National Tubewell Construction Co.

   iv) National Tubewell Electrification Co.

   v) Mechanized Construction of Pakistan.

   This action considerably relieved the public water agencies in various fields and has certainly improved the implementation capability in the water sector in general and reclamation programme in particular.

b) Encouragement of local private firms of consulting engineers for carrying out surveys, designs and preparation of water development projects. A number of such firms are already working for WAPDA on surface and ground water development projects.

c) In line with the high priority given to the salinity control and reclamation programme, Master Planning and Reivew Division of WAPDA revised the 21-Year Accelerated Reclamation Programme prepared in a great hurry by the Federal Planning Commission during 1973. This was made possible with the help of World Bank financing who engaged Messrs. HARZA Engineering Company International to assist WAPDA in this endeavour. The project

prepared by the Master Planning Wing of WAPDA is intended to provide a base for long term implementation of government's investment programme in the field of irrigation, drainage, saline soil reclamation and flood protection. The project would also have the objective of further developing the capabilities of WAPDA and other federal and provincial agencies for the independent continuation of planning in these fields.

This package deal has certainly improved the national capabilities to plan and implement its land and water development programmes without seeking foreign technical advice and consultancy. However, the success of this effort will be tested in future when the projects conceived, planned and implemented by the local experts are put into operation.

FUTURE COURSE OF ACTION

Based on the design criteria adopted under revised strategy, preliminary proposals for a 21-Year Accelerated Reclamation Programme were formulated in September 1973 by the Federal Planning Commission, with the assistance of a sub-committee comprising provincial and federal organizations. When these proposals were transmitted to the provincial governments for their formal acceptance, a number of additional items were included by the various provinces and also it was emphasized that time span for the completion of this programme should be reduced to the minimum. The task of final review and consolidation of these proposals into a working plan was assigned to the Master Planning and Review Division of WAPDA.

The programme which has been finally issued spreads over a period of 21 years commencing from 1974-75. The estimated cost of this programme at the price level of 1975-76 is Rs. 30,470.91 million(U.S. $ 3,047 million). Although this programme has a number of elements, the major segments of this programme are indicated below:

1) Area Served (in million acres) = 22.36
2) Number of new tubewells = 38,000
3) Replacement of damaged/deteriorated tubewells between 1974-1995 = 21,000
4) Open surface drainage(length in miles) = 48,000

The redeeming feature of this programme is that on the average it requires a minimum annual investment of Rs. 1,451 million constantly for the next 21 years. This amount may go up further depending upon the level of general inflation and escalation of prices in future. The big question is that shall it be possible to set aside such a big amount of money for only a small segment of water resource development in the country. The other equally pressing problems of water management which would be competing with this programme are execution of flood control and protection measures, urban water supply, extension of the surface canals, remodelling of existing canals and construction of new storages.

The situation can be best explained by looking closely into the allocations for the reclamation programme since its beginning in 1960 in the following table:

TABLE-V

Plan Period	Planned Allocation (Millions of Rs.)	Actuals (Millions of Rs.)	Shortfalls (Millions of Rs.)
1960-65	2,500	259.02*	2,240.98* (89.6%)
1965-75	4,679	1,809.75**	2,869.25 (61.3%)

* Accelerated Reclamation Programme 1976 - WAPDA.

** Fourth Five Year Plan Document for 1965-70 and WAPDA Report for 1970-75.

For whatever reason, it has never been possible to allocate financial resources at par with the requirements set out in various reclamation plans

as well as regional development plans prepared by various foreign consultants of WAPDA and approved by the Government of Pakistan. One may hope for improvement in future but there could not be any dramatic upshot in the availability of financial resources in the short run. Instead one can see that a number of unforeseen expenses have to be incurred which escape the planning exercises. An example of such expenditure can be the cost on repairs of various damages which have been appearing in succession at Tarbela. Such emergent repairs naturally erode the allocations reserved for developments.

There are a number of options which can be exercised to cope with the situation:

1) To re-tailor the planning, designing and implementation of of reclamation projects according to the availability of resources. This option besides other snags would introduce a number of uncertainties about the time horizon when the reclamation programme can be completely implemented. There will also be the danger that the speed of deterioration may be faster than the speed of the remedial measures so that there is a negative improvement despite huge investment. Naturally this situation has also to be averted.

2) Define the tasks which can be easily tackled by the private enterprise and make a well-designed programme for the training and motivation of the farming community to undertake this task. The remaining work which is beyond the technical as well as financial capabilities of the farming community should be handled in the public sector. This exercise can form an integral part of the Master Plan recently completed by WAPDA. In this way there is a possibility that the entire areas of Indus Basin can be treated within the foreseeable future and at a price which may not be unbearable for the nation. Flexibility and success of the private investment has been tested and confirmed during the crucial moments of Third and Fourth Plan periods. When the public resources were hardly available to discharge previously committed liabilities, private sector was going at top speed to install over 10,000 tubewells every year. Given the proper incentive, technical guidance and institutional support, the farming

community can be excited to undertake a number of on-farm improvements also to fulfil the dream of planners to produce four to five times more than the current production level in the Indus Basin.

CONCLUSIONS

1. The problems of waterlogging and salinity were time dependents, but the pace of collecting data, planning, designing and implementation of remedial measures was regulated by the availability of financial resources, which have always been in great demand.

2. Despite the fact that in 1960s it had been recognized all over the world and particularly in the developed countries that development and management of land and water resources have a very strong cultural and socio-economic bias, the consultants from these countries responsible for planning, designing and implementation of these programmes were still concentrating on the scientific and engineering solution of the problem only and consequently the data collected pertained only to the engineering parameters. The plans which were formulated and implemented on the basis of this data, had no relationship with the socio-economic setting and the management capability of the beneficiaries. Social, cultural and managerial changes implied by the proponents of these programmes for the achievement of the planned objectives naturally were difficult to come by, without proper motivation and education of the farmers and their full participation from initiation to the implementation of these programmes.

3. A number of agencies have been engaged in collection of the data on the nature and the extent of the problem from time to time and each has been following a different set of definitions. Adequate efforts were not made to standardize the definitions of the water and soil qualities or depth to water table for waterlogging, neither an attempt made to review the type of data required to plan these multiobjective projects on the modern scientific basis.

4. For a conceptual change from purely reclamation and drainage measures to a multiobjective ground water development programme, a number of actions were required to be taken, in addition to installation of tubewells, construction of surface drains and remodelling of irrigation channels. These were not included in the project designs on the consideration of cost

and yet in the balance sheet, it was claimed that agriculture production will increase manifold. This apparently could not happen.

5. The data being collected now also does not cover fully the cultural and socio-economic aspects of the problem areas likewise, watercourse studies undertaken by WAPDA do not include investigation for outlet design, location and alignment of watercourses, without which it would be impossible in the future programmes to plan on-farm water management properly.

6. Well-established international methods for drainage and reclamation (surface and sub-surface horizontal drains) were not adopted on the pretext that tubewells can serve as multipurpose project for drainage, reclamation and augmentation of surface supplies. The Indus Basin was, therefore, converted into a research laboratory to test the validity of some untried concepts and even those concepts which were attempted in the developed countries and given up.

7. Tubewells no doubt provide a quick relief to the waterlogged areas by the rapid draw down of the water table. This relief is, however, temporary as the conditions tend to reverse as soon as the tubewell becomes inoperative for one reason or another. This has been demonstrated in the existing SCARP areas ; the water table has risen very quickly in areas where the public tubewells were abandoned due to higher salinity or mechanical break-down of the tubewells.

8. The main justification for adoption of the tubewells as a drainage measure came from the possibility of using drainable surplus to make up the water shortage in the irrigated areas. It has been, however, discovered that only 20 to 30 per cent of the water pumped out could be actually utilized effectively on the farm, the rest being lost in transit. Therefore, besides a temporary relief as a drainage measure, tubewells could not boost the agricultural production to the planned altitudes.

9. Tubewells also could not succeed as an agent of socio-economic revoluation as it did not recognize the traditional evolution of an almost autonomous water management unit created around a watercourse. One public tubewell serves 2-3 and in some cases four outlets which creates formidable problems of coordination and management. If the size of the tubewell was restricted to such limits that it could serve only one outlet, the chances of its success would have been brighter.

10. Law of Average was applied ruthlessly to determine the mixing ratio between the canal supplies and the tubewell supplies so that the mixture of the two is fit for irrigation uses, under the conditions prevalent in the Indus Basin. This was possible at planning stage when the neat computations were being done on the computer. In transferring this paper planning into the field there were a number of lapses resuling into following anomalies:

i) The tubewells were not located at appropriate sites. The quantity and quality of water pumped by a tubewells was such that available canal supplies could not bring down the salt content to within reasonable limits. This has resulted into secondary salinization in large tracts of land within the project areas. On the insistence of farmers, a number of tubewells puming marginal and poor ground water had to be abandoned.

ii) Appropriate tubewell designs, mixing chambers, bifurcations and trifurcations were not implemented at site resulting into inappropriate mixing and distribution of the water from the two sources.

iii) Without complete rehabilization of the farmers' ditches to enhance their carrying capacity, huge quantities of tubewell water were pushed into these channels. This not only resulted in colossal transmission and distribution problems but also added to the water losses in the system. In a number of marginal cases, the tubewell water submerged the outlet structure reducing thereby its discharging capacity to such an extent that desired share of canal supplies could not enter the watercourse. This further increased the salinity in the integrated surface and ground water delivered to various farms.

Superimposed over these distribution problems were the poor on-farm water management practices of the poor farmers and uneven lands to be irrigated which multiplied the salinity hazards rather than providing a permanent relief. Some of these problems could also be averted if the integration of surface and ground water was designed on the basis of each outlet rather than a distributory or a canal system. To do this again, the design of the tubewell had to be different from the one adopted in these projects upto 1970. Apparently a smaller tubewell would have been installed which would be free from a number of problems associated with big capacity tubewells.

11. Local participation has been minimum in the planning, designs and implementation of the public sector tubewell programme. This meant high initial as well as recurring cost in foreign exchange for the execution and management of these tubewells. The cost-economics, managerial convenience and environmental appropriateness of these projects could be considerably improved by using local material, local technical know-how and taking into confidence the beneficiaries of the project areas. Purely as an irrigation venture, nearly 300,000 small capacity tubewells using indigenous material installed in the Indian Punjab can be quoted as an alternative example of comparative success and effectiveness.

12. A number of research studies have been undertaken at the Mona Experimental Station of WAPDA, Directorate of Land Reclamation Research Stations spread throughout the country, Irrigation Research Institute, Lahore, in the past and a number of such studies and investigations are being carried out by the engineering universities and other institutes in various problem areas related to salinity and waterlogging in Indus Basin. In some cases there is multiplication of efforts as the operations are being repeated. In other cases, the research is being conducted by agencies which are also responsible for planning and implementation of these reclamation programmes. In all such cases, normally there is a tendency to support the declared concepts and notions of the agency.

RECOMMENDATIONS

1. The fresh data being collected for a Master Plan should be subjected to an independent review to ensure its accuracy and universal acceptability and applicability.

2. The post-project monitoring and evaluation efforts should be suitably strengthened and placed under the direct control of the Federal Ministry of Water and Power. Besides monitoring the operation and management of tubewells in the SCARP areas, the related research efforts at Mona and other research centres should also be monitored for quality control and unbiased interpretation of experimental results.

3. The research and development activities in various organizations and institutes should be coordinated and periodically reviewed to ensure that scarce national resources are being effectively channalized for the improvement of planning methodologies, designing techniques and management of drainage, salinity control and land reclamation programmes.

4. Water and Soil quality standards should be properly defined for various regions of the country in relation to the land and water resources and the management practices. In the absence of a consensus, standards recommended in U.S. D.A. Handbook 60 should be adopted.

5. As a supplement to Master Plan prepared by WAPDA, areas should be delineated where only drainage measures are needed, where drainage and reclamation measures are needed and where drainage reclamation and integration of surface and ground water as a supplement to irrigation supply is feasible. The projects for these areas should be planned accordingly.

6. Where the tubewells are used purely as a measure of drainage, their location and design should be such that drainable surplus can be exported from the area without any interference with the irrigation system. In this case, the capacity of the tubewells has to be as big as possible with the local equipment and machinery because the bigger the drainage well, the better the cost-economics as a drainage measure. For irrigation tubewells, however, the capacity has to be decided on the basis of outlet capacity, size of the area on one outlet, quality of ground water to be mixed with surface water, soil salinity and on-farm water management practices. The area served by each outlet should form the nucleus for integration of surface and ground water and design parameters fixed accordingly.

7. Public sector tubewells should be installed only in those difficult areas where private investment is not possible. All the areas with sweet water should be left for private tubewell development and adequate incentive should be provided to motivate farmers to install their own tubewells on the basis of a planned grid to be prepared as a part of the Master Plan and information freely made available to the rural community. Institutional arrangements should be made to provide technical guidance as well as financial assistance to the farmer at the farm gate rather than farmers running around. Rural electrification should be assigned the highest priority.

8. Where only drainage measures are to be adopted, preference should be given to the horizontal surface/ sub-surface drains, depending upon the physiography of the soil, level of the ground water and opportunities for the disposal of drainage effluent. Tubewells should be adopted as a measure of drainage only where the pumped out water can be properly mixed in such

proporations that resulting supplies are totally harmless for irrigation purposes or other measures are not feasible on technical grounds. The fluctuations in the availability of canal water during various seasons have to be fully kept in view in not only designing such tubewells but also in preparing their operational criteria.

9. Purely drainage tubewells should be operated for longer hours during summer when the disposal of highly saline effluent from these tubewells can be safely disposed through the flood waters of the rivers. During winters, only those tubewells should be operated which pump out water which becomes useable after mixing with the available water from the local irrigation outlets.

10. For a public sector project, planning parameters should be extended to include re-location/re-designing of outlets, re-location/rehabilitation/lining of the watercourses, if necessary, and renovation of on-farm water management practices. While all these elements can be planned and designed optimally as a single system, the responsibility for execution of various elements can be apportioned between the public and private sectors judiciously. It is, however, necessary that various project elements are executed simultaneously so as to derive ptimum project benefits from the scarce financial investment.

11. The control of saline tubewells and drainage network meant for drainage only has to be kept in the public sector both for the implementation and operation. For the irrigation tubewells, the operation and management should be preferably handed over to the farmers' association or if no such association exists, to individual farmers on appropriate terms and conditions to ensure that full use is made of these facilities throughout the service areas.

12. The damaged and deteriorated tubewells in the project area should be immediately replaced. The new tubewells should be managed in the public sector only if the quality of ground water is not fit for direct application. The replacement tubewells should be so located that there is one tubewell on each outlet rather one tubewell for two to three outlets.

13. For the overall policy making, coordination and watching the process of implementation as well as operation and management including post-project monitoring, an appropriate institutional arrangement is necessary. This arrangement has to be multidisciplinary in nature derived from disciplines such as irrigation,

drainage, agriculture, cooperatives, marketing, financial institute (banks) and other responsible for the overall area development. An autonomous Reclamation and Drainage Board is perhaps best option. Care has to be taken, however, that this Board is manned by suitable professional experts from various disciplines to avoid the pitfall of a similar organizational structure created in 1964 but given up later.

14. Financial resources of public and private sector should be mobilized and pooled to launch a national campaign to eradicate waterlogging and salinity which is a prequisite to restore the normal health of irrigated lands and to modernize irrigated agriculture in Pakistan. If this is not done quickly, it would be difficult to sustain a growth rate commensurate with the national aspirations of self-sufficiency in food, uplift of backward regions to reduce regional disparities, faster growth of GNP, more job opportunities and social amenities and more equitable distribution of income. This is inevitable as none of the two sectors can shoulder this responsbility separately.

15. It may never be possible to recover adequate revenue from the direct beneficiaries of land reclamation and drainage programme. A reclamation cess may, therefore, be levied both on the direct and indirect beneficiaries of this programme. While the direct beneficiaries are well-known, the indirect beneficiaries may include the communication sector particularly the rail and road departments, agro-industry and commerical enterprises which would be affected as a result of waterlogging and salinity problems in various parts of Indus Basin.

16. The process of planning, programming and budgeting is too much centralized at the federal and provincial headquarters. Present arrangements may be appropriate for predominantly urban society, but in a rural setting like the one in Indus Basin, the basic infrastructural facilities for conceptualization, planning, programming and budgeting must be instituted at the district and sub-divisional level forthwith and taken down to the small towns and villages later on. These units should operate in close liaison with the political machinery at these levels so that through the active local participation full benefits can be derived from the land reclamation and drainage programme.

17. The conventional approach for planning, evaluation and decision-making needs to be substituted by a multidisciplinary

approach assisted by appropriate mathematical models, systems analysis and decision theories in order to select the most appropriate project design for the land reclamation and drainage programmes.

18. Reclamation and drainage project should constitute a part of rutal development programmes which must include establishment of agro-based industries. This will create more job opportunities and consequently improvement in the socio-economic conditions of the rutal population. Besides providing a sound base for the land reclamation and water development programmes, it will also check the flight of rural population to the urban centres.

19. The graduate study programme at the national universities should be gradually reorganized to introduce the inter-disciplinary and multi-disciplinary curricula and research programmes so that the engineers and scientists coming out of the universities can apply the latest technology for planning and management of the future reclamation programmes.

20. Under the programme of technical cooperation amongst the developing countries, institutional weaknesses in the local universities as well as water agencies can be removed. Help can also be sought from international training and research programmes sponsored by FAO, UNESCO, UNDP, WHO, Colombo Plan, US AID, For Foundation, Rockefeller Foundation, UNICEF and many other bilateral programmes of technical assistance. There is, however, need to redesign these programmes to improve their effectiveness.

21. Research and Development efforts should be steppted up to explore the non-conventional sources of energy such as solar energy with a view to bring down the cost of installation as well as operation of solar energy installations. The U.N. Programme to install four Solar Energy Centres in Pakistan between 1979-1981 is a very welcome move and this pilot project efforts should be pursued very earnestly. Simultaneously, the necessary tools to use this source of energy such as solar pumps for tubewells and drains and motors to operate diversified forms of farm machinery should be developed quickly to not only benefit from these efforts, but to trigger a change in the rural setting, so that over 50,000 villages in Pakistan could be provided with power within 10 to 15 years period for supporting reclamation and irrigation projects, domestic light and agro-based industries. The isolated efforts in the irrigation, drainage and industrial sectors are bound to yield sub-optimum results.

BIBLIOGRAPHY

1.	Bokhari, S.M.H.,	1970	Theory of Land Reclamation.Published in WAPDA Journal "INDUS".
2.	Bokhari, S.M.H.,	1975	Management of Water Resources under Different Socio-Economic Conditions-A Ph.D. Dissertation submitted to the Committee on Arid Land Resources.The University of Arizona, U.S.A. November,1975.
3.	Bokhari S.M.H.,	1975	Ex-Post Evaluation of River Basin Development in Pakistan. Proceedings of the U.N.D.P./U.N. Inter-Regional Seminar on River Basin and Inter-Basin Development held in Budapest, Hungary, September,1975.
4.	Cohan, J.L.,	1973	An Assessment of Multiobjective Solution Techniques for River Basin Planning Problems. Master's Thesis submitted to the Department of Civil Engineering System's Laboratory, Massachusetts Institute of Technology, September,1973.
5.	Cohan J.L., and D.H. Marks.	1975	A review and Evaluation of Multiobjective Programming Techniques, Water Resources Research, Vol.II, No.2 April,1975.
6.	D.W. Greeman, W.V. Swarzenski, and G.D. Bennett,	1967	Ground Water Hydrology of the Punjab (Pakistan).
7.	Duckstein, L.,	1974	Trade-off Between Models and Information in River Basin Planning. Paper at the Fall Annual Meeting of the American Geophysical Union, San Francisco, California, December,1974.
8.	Fraser, I.S.,	1958	A survey of Land Forms, Soils and Land Use of the Indus Plains: Government of Canada (Colombo Plan Cooperative Project).

9.	Government of Pakistan (Planning Commission)	1970	Document for the Fourth Five Year Development Plan.
10.	Government of Pakistan (Planning Commission)	1973	Preliminary Proposals for An Accelerated Programme of Waterlogging and Salinity Control in Pakistan by Planning Commission, September,1973.
11.	Government of Punjab, Pakistan.	1973	Future Strategy on Waterlogging and Salinity Control, February, 1973.
12.	HARZA Engineering Co. International.	1963	A report on an Appraisal of Resources and Potential Developments in Water and Power Sectors-Prepared for WAPDA., September,1963.
13.	HARZA Engineering Co. International	1964	Programme for Water and Power Development(1965-1975). Master Plan-Initial Phase, January,1964.
14.	Haveman, R.H.,	1972	The Economic Performance of Public Investments: An Ex-Post Evaluation of Water Resources Investments. Published by Johns Hopkins Press,Baltimore, U.S.A.
15.	Howe, C.W.,	1974	The Effects of Water Resources Devlopment on Economic Growth.Paper for meeting of U.N.E.S.C.A.P.Committee on Natural Resources,November, 1974.
16.	Indus Basin Review Mission	1969-70	Report of Indus Basin Review Mission 1970.
17.	Lateef and Shamsi	1964	Proceedings of a Symposium on Waterlogging & Salinity sponsored by Pakistan Engineering Congress, October,1963.
18.	Leiftinck,Pieter,A., Robert Sadove and Thomas C.Creyke,	1968	Water and Power Resources of West Pakistan.Published by the Johns Hopkins Press,Baltimore,Maryland,for the World Bank.

19. MacCrimmon, K.R.	1973	An Over-view of Multiple Objective Decision Making. The University of South Carolina Press.
20. Pakistan Engineering Congress Committee on Waterlogging and Salinity	1978	A Report submitted by the Committee to the President of Pakistan.
21. Soil Survey of Pakistan	1973	Effects of Tubewell Water on the Lands of the Salinity Control and Reclamation Project I.
22. Soil Survey of Pakistan	1978	Nature and Magnitude of Salinity and Drainage Problems in Relation to Agricultural Development in Pakistan- Pakistan Soils Bulletin No.8, April 1978.
23. Tipton & Kalmbach, Inc.WAPDA Consultants	1967	Regional Development Plan for Northern Region in 5 volumes.
24. U.S. White House Scientific Panel on Waterlogging and Salinity.	1964	Report on Land and Water Development in the Indus Basin.
25. WAPDA(Master Planning Division)	1976	Accelerated Reclamation Programme for Pakistan.
26. WAPDA	1978	Annual Report 1977-78.

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APPENDIX-I

INDUS BASIN SOILS

GEOLOGY

Geologically, the Indus Basin is part of a broad rift or downwarp that extends westward from the Bay of Bengal under the flood plains of the Ganges and then across the India and Pakistan to the Arabian Sea. This has been filled up by silt and sand deposits carried down by the River Indus and its five tributaries.

Of the nearly 50 million acres in the Indus Basin one or two million acres are occuped by the river channels and streams carrying fresh surface water. The tidal and salt flats of the Indus delta occupies another two million acres. Most of the remaining area was shaped by the rivers as they wandered over the plains, and is covered with alluvial sands, silt and clay.

LAND FORMATION

Five distinct forms of land were created by the major river actions over geological time horizon. These are briefly discussed hereunder:

a) Active flood plains, covering about 5.2 million acres, lie adjacent to the rivers and are inundated during the monsoon floods, when rivers often change their courses and silting and scouring takes place on a very big scale. The soil so built up is highly permeable and when floods recede, the excess water is drained off automatically from higher land to low-lying areas and ponds.

   These areas are cropped during winter for Rabi crops and the yield is reasonably good due to this flooding. As would be naturally expected the soils so formed have coarse sand in the upper reaches of the rivers and fine sand in the lower delta region.

b) Meander flood plain. This area adjoins active flood plains of major rivers or recently abandoned river courses. Mainly these areas were created by the river in former times as they changed their courses in meandering across the land. The relatively coarse soils of the meander flood plains are minutely stratified in a complex pattern. Ancient bars, meander scrolls, levees, and oxbow depressions remain stencilled on the land surface even after irrigation levelling, and still tell the story of ancestral rivers and prior streams.

c) Recently-abandoned river channels. These areas are bordered by ancient natural levees. Such areas are in abundance in the central portion of the valley, and form natural drains. There are numerous marshes and swamps and the area is often water-logged. The levees are usually above the level of canal command, and are unirrigated or even uncultivated.

d) Cover flood plains. These were formed by slow moving sheet floods that deposited a very flat cover of fine-grained alluvium. In some places, these lies next to active flood plains and are still annually inundated by the rivers; in other areas the active flood plain is bordered by relatively high meander flood plains over which the river wandered in past times before it cut its present channel.

e) Bars. Farther from the rivers and still parallel to them, lies belts of cover flood plains, which are extremely level and do not show any sign of modification by meandering rivers or sheet floods. These are called "bars", and are thought to be formed by the ancestral rivers before the cutting of the meander and cover flood plains took place.

They are covered with highly uniform soils of sandy silt, and are the most fertile regions of the Indus Plain. They are a few feet higher than the meander flood plains or cover flood plains, and are usually separated from them by low bluffs cut by the meandering rivers.

North and northwest of the Indus valley lie uplands, which are highly irregular in form, hilly, and eroded with small alluvial basins and fans separated by older rock.

The "bars", the meander and cover flood plain and portions of rolling and level sand plains(wind blown and alluvium) which altogether total 37.5 million acres, are the areas which can be put to any profitable agricultural use, where the soils were sufficiently permeable and not uneconomically saline.

NATURAL SLOPE

The entire Indus plain is a flat land mass, having an average slope of only one foot per mile from the base of Himalayan foot hills in the north to the ocean in the south.

PHYSIOLOGY AND CHEMISTRY OF THE SOIL

i) Soils are mostly sandy or sandy loams with clay contents seldom exceeding 15 per cent in a top depth of 10 feet. There are,