Water Requirement of Riverain Area of Sindh

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M. H. Panhwar

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INTRODUCTION

I was invited to attend and speak at a conference at Badin on 27th July 2000 on "Whether or not to construct Kalabagh Dam". The next day, the Daily "Kawish" reported that I spoke against construction of Kalabagh Dam, and the speech did not mention any thing on or about Kalabagh, and I wrote a letter to the DAWN, which was published by them as is reproduced below.

Facts about groundwater in Sindh.

(i) In Sindh, fresh groundwater is only in 10% area, but even this is underlain by brackish water, which rises every time pumping is done and with pumping for 30,000 to 40,000 hours, all this water will turn brackish. This is going to happen soon and there will be no fresh water tube-wells in Sindh.

(ii) If 4,800 proposed tube-wells are installed in riverain area, they would pump huge quantities of groundwater each year. This quantity of water would need annual replenishment and such a quantity is neither available, nor can be spared.

(iii) When existing fresh ground water goes saline, we would need extra surface water to maintain existing cultivation, and this has to be provided.

Parts of my speech were also shown on the PTV on the very day. I want to point out that the reporter did not convey the correct views expressed by me.

M.H. PANHWAR
Karachi,
11 August, 2000.

Actually, I was called upon to speak at the conference only for five minutes, and on the subject "Ground Water in Sindh" which I have been investigating and studying for the past fifty years. A summary of my findings on the subject could only refer to and highlight the seriousness of the plight of the Riverain area of Sindh in case annual floods failed to visit the area and also the need and availability of extra water in the shape of fresh ground water in the said area, which was already fast turning saline. The tragedy is that Sindh believes that WAPDA is taking sides and Sindh Government has not given a serious thought to the problems of Sindh's riverain (Katcha) area. The local residents in the area being small minorities in adjoining Talukas have no political voice and the politicians returned to Assemblies have no full awareness of their plight, and sadly enough they do not know the solution of their problem. "Ground water" has not been much of a subject to be understood and explored by the Engineering or Irrigation Departments of our Universities or even of Governments. The one time Government supply agencies and technical services working as drilling contractors for the farmers have today lost involvement or even capability. I have written these pages in defense of the neglected area and have pin-pointed and dwelt on the problems for the readers in a layman's language. The highlights of what this book-let discusses in some details are:

(i) The riverain or Katcha area of Sindh between Kashmore and its Indus delta up to the sea coast, within the Flood Protective Embankments, is 2.112 million acres, which is roughly divided into the present and the abandoned river channels (600,000 acres), forest lands (450,000 acres), roads, settlements and government structures (50,000 acres), agriculture land (1.0 million acres, of which more than 60% is Kabuli or private land and the rest is Nakabuli or Sindh government land).

(ii) The exact figure of the Nakabuli land is not known as some of it has been leased out to various individuals, parties and agencies. The forest department also keeps on leasing out the land.

(iii) Before the opening up of Tarbela dam in 1973, the Katcha area received 300,000 cusecs of water almost every year (98% of years), 400,000 cusecs in 86% years, 500,000 cusecs in 77% years, 600,000 cusecs in 55% years, 700,000 cusecs in 28% years and 800,000 cusecs and above or super-floods in 13.3% years.

(iv) On the preserved moisture left by yearly flood water were raised forests, horticultural crops (melons and vegetables) and field crop (wheat, oil seeds) in Rabi.

(v) Area flooded and not under Rabi crop grew luxuriant grasses and pastures, and even in areas not flooded, pastures were supported by capillary action of moisture rising up from water table, and on it thrived animal husbandry, not only animals of Katcha area but also those brought form adjoining barrage areas and invariably from Thar and Kohistan from March to July.

(vi) Wahurs, Dhoros, Dhoris (abandoned channels) and active river channels produced abundant fish and fauna, and fishing was a large industry in Sindh.

(vii) Permanent population of Katcha area was 750,000 in 1972, but a large number of migratory and temporary people of out-side areas too were engaged in the cutting of outworn or excess forest trees, tens of thousands, in making wood products, in making wood products in animal husbandry, fisheries and in plying tens of thousands of boats as means of river transport and fishing.

(viii) Jobs appropriate to those for the riverain area in hundreds of ways had made people of the Katcha and adjoining areas prosperous.

(ix) Boatmen were once hit badly by railway traffic since its inception in 1861. Being directly in competition with the government owned railways, but the river, their lifeline, existed and they survived. The boatmen in Sindh are today being decimated because of Indus in its passage through Sindh, and Sindh's hundreds of lakes, are being devastated and de-watered and literally killed. And the governments of the day care a hoot about it all. Hundreds of river ports have decayed and gone out of service and tens of thousands of the boat-men and men of fishing communities are languishing in penury. The government establishes Municipalities, Notified Area

Committees, important mundies and settled business communities and workmen therein, are flourishing but not the boatmen and others dependent for living on the river since thousands of years past.

(x) New canals were being constructed and old ones extended and the area under cultivation was being increased from 900,000 acres in 1843 to 3.0 million in 1900, but no provision was made for settlement of boatmen as farmers on new lands, which as per general policy were being sold or allotted to big land-holders as they helped the government in maintaining law and order and helped in execution of government policies. Exactly the same “care a hoot for it all” is being adopted towards, the fate of the river, and the vast human, animal and vegetable populance that it feeds and sustains for the rest of us all.

(xi) The flooding of Katcha area annually with minimum of 300,000 cusecs in 98% years and 400,000 cusecs in 86% years, gives the area historical right on water for agriculture, animal husbandry, forest and fisheries, and this right must be met at 100% by the government. Some fishermen at Rohri had fishing rights to catch pala (hilsa) fish on up streams of Sukkur barrage to Khwaja Khizir’s island. Sukkur barrage had no fish ladder and fishermen asked for “fishing rights” south of the barrage head-works. It took 30 years to settle the case. Mean while fish ladder was provided for at Kotri barrage, but alas! That too failed to work as it was not designed on actual study of movement of hilsa. Fishermen there asked for right on the down stream of Kotri barrage, but before it was accepted; water flow down stream of Kotri barrage dwindled into occasional streaks only.

(xii) Kotri barrage depended on its supply of water in Rabi season on seepage of water from lands within and out-side Flood Protective Embankments to the river channels and this regenerated water had minimum discharge of 3,000 cusecs at Kotri barrage, in addition to filling Wahurs, Dhoros, Dhoris and supporting fish and agriculture, wherever pumping was resorted to form Dhroros and the main channel. Today due to non-flooding of the riverain area, situation has changed and the scanty seepage from the embankments take place only from September to January, while form February to June embankments in turn absorb water form the main channel, if available. This pattern has affected availability of water almost directly down stream both of the Sukkur and Kotri barrages.

(xiii) During the inundation season flood water not only recharged ground water in the Katcha area but also in adjoining barrage area. Now in the reverse situation ground water in adjoining barrage areas in going to be depleted from root zone, and needing more irrigation water for raising crops.

(xiv) The riverain area in Sindh has fresh ground water in 50% area only and it is saline in the rest 50% of its area. In order to raise only a single Rabi crop on tube-wells in the 50% of area, 1.8 MAF (million acre feet) of water is needed. For the rest of the 50% area surface water required is 2.7 MAF as its transportations losses would be 50% of water actually delivered to the field. This 50% is conservative figure as WAPDA’s calculations make it 100%. Total water requirement shall be 4.5 MAF for 1.45 million acres of land under agriculture and forestry.

(xv) This does not include water needed to dilute sea water, along the coast to regenerate crustaceans water, along the coast to regenerate crustaceans (shrimps both giant and sea water lobsters and crabs), hilsa and other brackish water fishes and mangroves, which have dwindled to almost 5%. Today 100 boats catch the same fish as 5 boats were catching before commissioning of Tarbela dam.

(xvi) It would be uneconomical to raise forests on tube-well water. Forest land can be distributed among landless farmers at 16 acres per family from riverain or adjoining areas to overcome resentment among the people for making Land Reforms un-Islamic. There is also an un welcome streak of thinking that land may be leased out to parties from other areas or given to foreigners in the name of 'Corporate Agriculture'.

(xvii) A tail end barrage is needed to stop flow of sea water in the river bed. When water becomes surplus it could be diverted by two canals to fill lakes in coastal area for water needs of human settlements and animals.

(xviii) Some assured quantity of water is to be allowed to flow to the sea year around to protect environments as mentioned in (xv) above.

(xix) Fresh ground water area in Katcha is in about 50% of total area of 2.1 million acres i.e., in 1.05 million acres. It is a bank of ground water in which water can be deposited during inundation season of a few weeks to about two months and withdrawn my time. This bank also has ability to provide overdraft in form of withdrawal over the deposit, during a particular year by allowing discharge from depth up to 50 feet economically, by spending more on power, a kind of "interest" and again charging the storage bank in the coming year or two. Withdrawal can be up to 10 MAF (million acre feet).

These in brief are the problems of Katcha area of Sindh, which need to be studied at top priority level, keeping in view the following:

(a) Along with the water requirement of the area, environmental study of the whole area may be undertaken by foreign consultants appointed by the Government of Sindh with assistance of aid agencies. The local consultants lack know-how, and Sindh strongly believes that WAPDA is taking sides, and therefore foreign consultants have to be responsible directly to the Sindh Government.

(b) Environmental impact of dams on Indus and its tributaries and their effects on the coastal area may be studied by foreign consultants and minimum flows to the sea worked out by similar consultants appointed by the Sindh Government.

(c) Effects of non-availability of water in the Indus, and tidal encroachment in the bed of river, which in turn has made adjoining areas unfit for cultivation and grazing, deterioration of shallow fresh water dug-wells, shifting of population and desertification, may be studied by foreign consultants, appointed by the Government of Sindh.

(d) Design of a tail end barrage to stop intrusion of sea water may be assigned by the Government of Sindh to foreign consultants.

(e) The best designs for tube-well in riverain areas may be studied and work assigned to foreign consultants. This should be the standard design to be enforced by law by the government.

(f) Sindh has very limited fresh water and it is slowly turning saline. Study of this may be undertaken to work out extra surface water required to supplement it in areas, where water has turned saline to save at least the tree crops raised on this water.

(g) A master plan is to be prepared to execute schemes arising out of the above studies.

The Sindh Government unlike WAPDA has no organization to supervise work of consultants. A committee of experts from private sector can be appointed to work as supervisory body possibly on full time basis and if projects are under taken at one time, supervision may be assigned to the some aid agency, or agencies but consultant may, more profitably work with the Sindh Government to win the trust of people.

This is just a preliminary paper and a guide-line on water requirements of Riverain area of 2,112,000 acres, which had made rise of Amri, Kot Dijji and Mohenjo Daro, the Early and Mature Indus Civilization, and subsequent dynastic periods possible, and until inception of the railway as a great highway. For the first seventy years since introduction of the Indus Flotilla in 1860 it suffered badly in terms of trade and dwindling of its ports, but its fish industry had survived. Since opening of Sukkur barrage it started losing ground and with the opening of Kotri barrage the whole industry dwindled. Since that date, cultivation in Riverain area started reducing and in years 1999-2002 sailabi cultivation was no more possible. Since Riverain area has historical rights to cultivate land in Rabi raise pasture and forests on rest of the area, it is responsibility of Government of Sindh to develop it to its past glory.

This preliminary study should be followed by detailed studies and planning of projects, before final preparation. A master plan needs to be prepared after study of recurrent environmental changes and their impact. The process should include rehabilitation of cultivators, fishermen, foresters and traders and settlement of villagers.

The author does not claim that this is the final report on the subject. It is just a guide line and only points out the problems.

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Author also takes full responsibility of various statements in the booklet, some of which may not carry due weight with some people, who have the same right to express their views, as author has.

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CHAPTER 1

THE NEGLECTED RIVERAIN AREA OF SINDH: THE PRESENT SITUATION, AND SUGGESTIONS FOR ITS DEVELOPMENT.

The Riverain Area.

The Riverain Area in Sindh consists of approximately 2,112,000 acres or 855,100 hectares, lying on both the sides of the main stream of the river Indus, within the two flood protective embankments. These embankments or levees had been constructed over a century from 1860, to 1960, and the river was virtually trapped within these embankments approximately ten miles apart, protecting roads, railways, towns, villages and above all the agricultural crops out-side them, from annual floods of the river. The pre-barrage inundation canals could also be given permanent mouths to ensure water supply according to levels in the river. The river having westerly tendency is in general now closer to the right (west) bank, rather than to left (east) bank. The levees or embankments are 6-8 kilometers form the main river channel, which is 1-3 kilometers, wide at most places.

The main active channel of the river, Dhoros (its abandoned channels) and sand and mud flats in general occupy about 29% of the riverain area or approximately 612,000 acres as per aerial photographs. Some of the Dhoros get silted up year after year, opening up fresh arable plots for agriculture. The rest of the area of 1,500,000 or 1.5 million acres is slightly undulating with generally the higher levels along the embankments and slopping towards the Wahurs, Dhoros and the main channels in the center. Wahur is abandoned channel usually connected to main channel at some point, but Dhoros are not, though they too are abandoned channels. However this is not a hard and fast rule, as wind and water erosions and depositions have caused good many mounds between embankments and the abandoned river channels. Of the 1.5 million acres, approximately 1,000,000 acres are agricultural land; 450,000 acres are forest land and the rest 50,000 acres over villages, graveyards and unculturable waste lands. These figures can vary by 5% to -5% due to recurrent changes and more or less annual flooding of riverain areas yearly, but total area within embankments naturally remains the same.

This land was flooded annually during the inundation season to various degrees and depths and the whole land profile got over-topped or inundated, under going a process of erosion and accretion of new banks, until the river receded to its active-bed. Water absorbed in the ground during floods, gradually seeps back into the main channel and Dhoros after inundation. This alternating charging and re-charging of ground with water and its seeping-out has created highly permeable and fertile alluvium soils. Before commissioning of Tarbela Dam in 1973, floods visited every year and inundated almost the whole agriculture and forest area. More than 300,000 cusecs (cubic feet per second) discharge was common in almost 100% years. Heavy floods over 800,000 cusecs arrived in 1914, 1929, 1942, 1948, 1956, 1957, 1959, 1973, 1975, 1995, i.e., 11 times in 90 years. This overall trend is to continue and the planning of riverain area has to take into consideration this fact. A flood of 500,000 cusecs occurring three times in four years caused no damage. Floods of 300,000 cusecs occurred almost each of the rest years and were beneficial, but did not flood total agricultural and forest land. Heavy floods of 500,000 to 600,000 cusecs caused some damage, but heavy floods to 700,000 cusecs and above, caused 75-100% damage to housing, Kharif (summer) crops, government buildings, river port facilities, the stored grain and animals and caused some human casualties. However people were happy for ensuing better prospects, i.e., Rabi (winter) crops on preserved moisture (Bosi). In recent years if flood water exceeded 500,000 cusecs, there also was damage to tube-wells and housing, chocking of dug wells, damaging government buildings like schools and hospitals and above all causing dislocation of population and animals.

Frequency of peak floods at down stream of Sukkur barrage for the years 1907-1976.

This is given in the table below:

Table 1.1 frequency of peak flood 1907-1976.

Flood exceeding causes	Frequency or recurrence times in 100 years.
300,000	98%
400,000	86%
500,000	77%
600,000	55%
700,000	28%
800,000	13.3%

(Source: WAPDA, 1976, Development of Riverain Area Part-I)

These are the figures prior to dams constructed in India, as well as Mangla, Tarbela and Chashma in Pakistan. Presently even the usual; 300,000 cusecs discharge is not possible in most of the years. Figures for year 1977-2000 are not available to the author. The major advantages accruing from annual flooding are:

- The soils in the area are generally highly permeable; they have higher horizontal permeability than the vertical one, a factor advantageous for recharging from the river, when in flood. Thus, helpfully, the soils in the area remain salt free.

- Horizontal permeability of the soils is disadvantageous too, in a much as the soils lose water to the river much faster. This disadvantage comes in the way of Sailabi cultivation. If the river recedes in August or early September soils lose moisture before sowing of crops in late October. Before commissioning of Tarbela, floods receded at the end of September and moisture was available for sowing crops in October.

- Except in rare cases, soil pH is 7.6 and higher at points, which are not flooded for years. Some of these high points are also having saline ground water underneath. Soils at these places have pH between 7.6 to 8.5 and usually over 8.0.

- After recession of floods, water seeps out towards the Dhoros and the river bed gradually, over many months. Until onset of next floods therefore, with a little soil working, crops are raised regularly on the preserved moisture on this soil. This type of cultivation on preserved moisture is called “Sailabi” or “Bosi” and had been traditionally practiced in Sindh for over 5,500 years or since the archaeologically called “Amrian Times”. It consisted of complex water management from Wahur to Dhoro and to the diminutive Dhori; these are from-big-to-small size and originate from abandoned channels of the river Indus. Water enters Wahur from the main channel in the inundation season or even when water recedes. Dhoros or Dhroi are not connected to the main course or Wahur. Water is led from Wahur to Dhoro by cutting a small channel, which fills Dhoro to the level of Wahur at the point of cut. From Dhoro water is led to Dhori to fill it up. From Dhori water is led to small fields each 4 to 8 acres area having dish shape and below the level of water in the Dhori. At point of water entry Wahur has same level of water as in main river Channel. But at various points along its length it has higher level than adjoining point of the river as bed has slope of about 12.2 CMS per kilometer and level of water in the Wahur will remain the same as at the point of entry.

- Though crop yields of Katcha lands, raised only on preserved moisture, are half of those in the irrigated Indus plains, but even without fertilizers, herbicides and pesticides, the yields double up if two irrigation doses are applied to Rabi crop from Wahur-Dhoro-Dhori, to meet deficiency of water during flowering and ripening of crops. Farmers knowing it have adopted the system for higher yields, wherever possible.

- Water which seeps towards the river bed also has low salinity; for example the Indus waters have total soluble salts (TSS) contents of about 150 ppm (parts per million) during the inundation season in the months of July and August, but seepage water form the ground, as received at Kotri barrage in the month of May, prior to the on-coming inundation, has TSS of 250 to 500 ppm. This regenerated water in the river is utilized in the down-stream of barrages, namely Sukkur and Kotri, and adds greatly to the economy. The Kotri barrage depends solely on seepage or regenerated water of the river after the inundation season. The Sukkur barrage has historical rights on water of the Indus, including seepage between Kashmore to Sukkur by this process. The Kotri barrage does not have allocated rights under 1945 Sindh-Punjab Water Agreement, but seepage water from embankments thus supplied for the past 40 years has created its own historical rights too and this quantity has to be supplied without fail each year.

- Dhoros remain filled with water to varying degrees and water is lifted from them for raising summer and winter crops Wahurs or recently abandoned channels are a few miles long and some times connected to the main channel. A Wahur nine miles long connected with the river at top end and not along its whole length will have water six feet (1.8 meters) higher than the nearby main channel at its tail end, if it has well developed natural embankments, due to slope of river bed, as well as the land, as discussed above. Thus Wahurs can be used for gravity irrigation at suitable points, and have been used as such through out in the past.

- Dhoros serve as fish stock breeding and farming ponds on natural phytoplankton and zooplankton created by solar energy as the only source of fish feed in the riverain areas of Sindh. Before creation of "One Unit" in 1955, Sindh produced 80% fresh water fisheries of Pakistan due to fishing form river channels and lakes filled by canals, and fish was sold at one third price of mutton. The fishing industry in the river has historical rights and the dwindled industry has to be re-activated.

- The main channel of the river is also able to support variety of fisheries and aquatic life and adds to economy of Sindh. The whole area of 2.112 million acres was highly productive supporting large population of fishermen, farmers, livestock grazers and boats-men. The availability of 40,000 boats on the Indus between Halla and the Arabian Sea in Thatta Sarkar in 1600 AD, as reported by Abul Fazal only shows the employment opportunities, the Indus had provided before commissioning of railways, between 1860 to 1900. There were live ports at every 6 to 10 miles and they buzzed with population and their activities.

When railways were built, no provision was made for settlement of boats-men and their supporting service men in irrigated areas. They were forced to accept life to tenant farmers and this hit them socially in Sindh's hierarchy of caste system, putting them into unpleasant situation. The business community at the ports was shifted to newly built railway stations by establishment of Notified Area Committees and allotment of land to them. Sukkur barrage did not have shiplock and this stopped direct boat traffic from the Punjab and NWFP to Sindh.

Some fishermen had some centuries old historical rights of fishing. Those at Rohri had rights to catch hilsa (palla) around Khwaja Khizir Tomb. Sukkur barrage did not allow hilsa to cross it to Khwaja Khizir tomb on its upstream. The fishermen asked for rights below the barrage head-works near Sukkur. It took 30 years to settle the case and when it was settled, the faulty Fish Ladder at Kotri barrage did not function and they asked for fishing rights below Kotri barrage. Before it was settled, water started flowing below Kotri barrage for less than 50 days a year and flows now only for a week or two.

- The main channel of the river between Guddu and Sukkur remained navigable for small boats almost throughout the year, and for nine months between Sukkur and Kotri until 1970s. In post Tarbela period, this industry has dwindled forcing fishermen and boatmen to become tenant farmers, as no allocation of land was made for these two categories of workers in Kotri and Guddu barrage land distribution. This results form wrong planning, and responsibility whereof lies on the governments of the day controlling railways, canals and barrages.

- With construction of barrages human resources, capital investment and government attention moved away to barrage areas and development in riverain areas became sub-optimal.

- The Indus River behaves as influent stream during the summer or the flood season, when water from its streams seeps into ground towards the flood protective embankments. During winter it behaves as effluent stream and water seeps out from the fields outside and within embankments to the river stream. Dhoros, Wahurs and Dhoris.

- Soils of the riverain area are fertile and free of salinity and of excellent quality. Sediments brought by river Indus from year to year have also enriched soils with macro and micro-nutrients, but these soils lack organic matter as compared to irrigated soils. This is specially so after the failure of flood occurring year after year, causing almost desert like conditions, due to lack of vegetative cover. Now it is an area in “low input-low output trap”.
- The entire riverain area was the most prosperous area in pre-barrages period but has been ruined economically in recent decades.

Indications by aerial photographs.

Aerial photographs were taken in 1953, 1967 and 1973. Comparison of land forms in the riverain area during the three periods show continuous changes in land forms on the surface. Satellite photographs can give recent pictures of land forms. These photographs show that in absence of water, salinity problems have increased heavily in the riverain areas.

Roads.

In the riverain area permanent roads may never be constructed even by Cooperatives or sugar mills or local authorities, as the total area is bound to be flooded twelve to thirteen times a century, destroying these roads.

Constraints to agriculture in riverain area.

Factors like high water losses in watercourses and fields due to high permeability, higher infiltration rates, and higher horizontal than vertical permeability (though vertical permeability is also much higher than in the Indus plains), have caused low irrigation efficiency and extra water allowance has to be made for it. Other constraints are: lack of infrastructures, no roads, no telephones, no telegraphs and no markets.

The present position of inundation water.

Ever since construction of the flood protective embankments, the whole of riverain tract used to get flooded, year after year, during each inundation season, from June to October. The people were conditioned to temporarily move away from the area during the period. But after indo-Pakistan Water Treaty of 1959, India's diverting waters for the irrigation purpose, and within Pakistan construction of link-canals in the Punjab and Mangla and Tarbela dams, the situation changed. Inundation water was reduced and riverain areas in Sindh no longer were flooded fully as before. Originally annual peak discharge of more than 300,000 cusecs of water in almost 98% years and more than 400,000 cusecs in 86% years, had ensured that the riverain area got nearly full flooded, and on preserved moisture good winter (Rabi) crops were raised annually, and luxurious pasture developed in rest of the area as grasses tapped shallow ground water, but now it is reduced to probability of once in every ten years or so, resulting into poverty, migration, unemployment, famine conditions, diseases and deaths. Poverty has led to infestation of area with dacoits, and poor riverain people are neither interested nor in a position to assist in eradicating them at their cost. Even if they want to, the government protection to them against criminals and dacoits is lacking.

Population.

The total population of the riverain area according to 1972 census was 750,000 people. Now, however, it is twice this figure, inspite of desertification caused by lack of food and the resultant migration. The concentration of population is in areas having tube-wells and forests. Recent Banana Bunchy Top Viral disease has resumed into abandoning of banana plantation in riverain areas below Moro to Ketibunder, and this has changed the population patterns in the whole area. The people have migrated away. The riverain areas if fully irrigated can support a population of three million people, in various trades, namely farming, fishing, transport and marketing, animal husbandry, forestry, etc. The constraints to development of the area are:

- Poverty of the people.
- Lack of capital to install tube-wells.
- Poor infrastructures.
- Brackish ground water in 50% of the riverain areas.
- Desire to keep area backward and un-surveyed so that it does not come under preview of Land Reforms and big land owners occupying the area are made to surrender the land and nor pay agriculture income tax.
- Uncertainty of the periodic low, medium and super floods, which disturbs and dislocates the regime and living patterns of the populace.

Tube-wells in the riverain area.

Prior to 1960 not a single tube-well existed in the riverain area, primarily on account of fear of losing it to the floods. After 1960s, however there has been continuous demand for the installation of new tube-wells.

The Dhoros are also exploited by way of pumping water from them for agriculture. Dhoros show virtually inexhaustible supplies of water if pumped in cautious and reasonable amounts. The Dhoros created recently by the river are 15-20 feet below the surrounding land and pumping from them induces seepage from adjoining lands towards them. They have proved to be much more economical than tube-wells, not only on account of low capital cost, due to elimination of under ground tube-well elements, but also due to less draw-down (drop in water level) at the pumping point or less suction or pumping head and thus creating economy on power for pumping. For the purpose of ground water development, Dhoros are a source of ground water, as they capture seepage water from adjoining areas.

Presently, there is no alternative, but to install tube-wells in this area to rehabilitate agriculture pasture and forest lands. The operation, maintenance and economy of tube-wells, is totally different from what it is in the irrigated areas, where tube-wells supplement the canal irrigation for the purpose of raising and promoting value added crops specially fruits, nuts or pomology and olericulture, which need more water than allocated quota during certain periods of the year, for optimum yields. Thus they play a special role in boosting the economy of already existing crops in irrigated areas. In the riverain areas, the tube-well installation and operation would immediately raise the question of most economical application of water to the crops. This factor alone would lead to new thinking, new analysis and new institutions for the support of the success of this experiment of raising crops on tube-well water alone. Due to the highest cost of irrigation water, the cropping pattern in the riverain area has to be totally different from that in the irrigated area. Farmers, extension workers, researchers and planners have to work to that end. If in every ten years, there is going to be flood of more than 500,000 cusecs in August, crops which tolerate flooding have to be investigated and introduced as summer crop, and there are not many such crops.

Agriculture land.

Of the 1.0 million acres of agriculture land approximately 0.45 million acres is privately owned called Kabuli and the balance 0.55 million or 550,000 acres is Nakabuli or State land. This land if disposed in pieces has to go to the people having Muhag or border rights of first refusal, if their holdings are less than 16 acres, although Land Reforms do not apply to riverain areas and these have now been declared illegal by Shariat Court.

Existing agriculture.

Traditional agriculture in the riverain area is based on Sailabi cultivation i.e., cultivation on preserved moisture for crops like wheat, oil seeds, winter vegetables, and melons, which all are winter crops. Kharif (summer) cultivated is carried out only on tube-well water is led from the main stream or Dhoros to low lying flat lands. Tube-well irrigation s limited mostly to sugarcane but some time cotton, sorghum, fodder, summer vegetables and summer oils are also raised. Use of tube-well water for raising mainly sugar-cane shows the general trend in use of pumped water for value added crops. It is encouraging that the future trend would mainly be to grow value-added crops, rather than conventional cereal culture or fodders which are un-economical to grow on tube-wells or lift pumps from Dhoros and are marginal on canal water even in irrigated areas. At present winter crops grown in the riverain area are winter vegetables, fodder, wheat, oil seeds, pulses and root crops specially onions, carrots and sweet potatoes. Melons and water-melons also form important non-tree fruit crops. Sugar cane where ever grown is the annual crop.

Forest land.

There are about 450,000 acres of government forestland in the riverain tract. These were supported by annual floods of the river Indus. The forest species establish themselves by natural selection, adopting themselves to the annual flooding for three to four months and depending on under-surface preserved moisture within the root zone for another three to four months due to their shallow tap roots system and for survival during the next four to five months, on the deep tap-root-system. In case of horticultural plants it is well known that taproots keep trees alive during the drought, but the fruit yields are either reduced considerably or fruit crop failure is common occurrence. It is probably the same phenomenon that the forest trees growth in Sindh dwindles during the “Off flood” years and recovery occurs during the “On flood” years with poor yields. Some forests of Sindh are known to have died of reduced to a mere xerophytes type growth, especially where flood water has not reached for some years. A good example is the lush green “Hilaya forest” near Kinjhar Lake, which perished due to lack of water. The common belief is that the forests need no regular irrigation water, but under the present circumstances without pump age from ground water sources, it is doubtful if they can survive or become economical. But whether such application of ground water to the present forest species would be economical, needs a thorough study and a further research. Whether any new forest species suiting to the present ecological conditions, need to be introduced for economic advantage or the species be continued to meet the running demand for supply of timber for mining, furniture, buildings and fuel, and this also needs studies.

Animal husbandry.

At one time riverain area was a paradise for animal husbandry in Sindh. The cattle owners from Kohistan, Thar and as far south as Kutch moved their herds to Sindh's riverain areas, after supplies of natural grasses growing on rain water in those home areas were exhausted. Some 1.6 million acres of Nakabuli (Government) lands covered with grasses, shrubs and bushes in Kotri barrage were not the only pasture. Private lands also formed pasture lands and when these were exhausted, cattlemen moved to the Riverain forest areas, with or without permission of the authorities, but surely with connivance of the lower staff of forest department. Since early 60s natural pasture lands in Guddu and Kotri barrages totaling about 2.7 million acres of government land were converted into agriculture lands. Many cattlemen moved to the riverain areas, over-stocked them but these pastures too have dwindled totally due to lack of flood in the riverain areas since mid-70s, disastrously affecting animal husbandry of the nomadic population of the riverain areas and also of Thar and Kohistan, who also moved annually with their animals to the Kotri barrage pastures and riverain areas.

Fisheries.

The Dhoros and the riverbeds were vital to the economy of Sindh in providing fisheries resource. Once Dhoros are pumped for irrigation and water is lifted, it carries away with itself natural fish food, phytoplankton, and zooplankton, and fry-fish. The third could be prevented by suitable filters, but the first two will be pumped out along with the fish eggs and larvae. This loss would reduce the fish catch from already a low figure of a few mounds per acre of pond area. This industry thus has suffered equally as agriculture and forestry.

Tube-wells for reclamation of the riverain agriculture land and forests.

Impact of tube-wells.

Tube-wells can be installed for re-activating the area. They will draw water from underground by creating a cone of depression, which will induce ground water flow from surrounding lands towards tube-wells. Most of water would ultimately reach out form river channels and Dhoros.

WAPDA's study (1976) shows that some 97% water drawn by tube-wells within one mile from the river bed will come form the river and 75% in case of tube-wells two miles from the river channel, clearly showing that regenerated water from the river available for Sukkur and Kotri barrages will reduce and only small quantity of ground water will come from water bearing strata under ground. To meet the deficiency, supply of water from storages would be essential to meet historical rights of Sukkur barrage as per 1945 Sindh Punjab Water Agreement and historical right created by forty years supplies to Kotri barrage form regenerated water. That riverain area has the right for cultivation of 100% Rabi crops in form of field crops pasture and forestry is a historical fact since Amrian Times i.e., for the past 5500 years. No attention is paid to this near-calamity state, as people affected are poor, tongue-tied and un-influential and can only think of and remain occupied in search of daily food.

Consequences of ground water development in riverain areas.

- Ground water development will lower water table within the riverain area. When water table falls below root-zone of frost trees they would decline in health, if not die altogether.

- Water table will normally fall by a few feet. If large number of tube-wells is installed for irrigating the area at 100% intensity, it will fall down by about five meters. This will dry up even the Dhoros, Dhoris, Wahurs and main stream, which support fish and also supply regenerated water to Kotri barrage. Forests will most probably die. Mining of water will also induce flow of gorund water from irrigated areas and deplete those areas of fresh ground water.

Occurrence of fresh ground water in riverain areas in Sindh.

The common belief is that, since the area has been flooded for over a century by the river waters, and year by year, and for the whole inundation season extending to many months each time, the fresh ground water of excellent quality is underlain in the whole riverain area and is also ever plentiful. Unfortunately this not true. It is almost a myth, as only in 50% of the area of total 2.112 million acres, ground water is fresh and in the rest of the area it is brackish and not only un-suitable for the human use, but also for irrigation and for animal husbandry purposes. Most of the time it is highly saline, but below Kotri barrage, salinity in most of the area is nearly twice as much as seawater i.e., 70,000 parts per million parts of water against 35,000 of sea water.

The following are observations on occurrence of ground water in riverain areas, starting from north near Kashmore to south near Keti Bunder.

- Ground water near the town of Kashmore in the riverain area on the right bank is brackish and unsuitable for human use. Ground water is suitable for irrigation 15 miles south of Kashmore and further south on the right bank to five miles above Sukkur barrage head works.

- Ground water on upstream of Sukkur barrage and above towns of Sukkur and Rohri is brackish on both banks within five miles.

- The same is the case of ground water on the down stream side of the Sukkur barrage below Rohri and Sukkur, for about three miles.

- Ground water is suitable from Guddu barrage head works on the left bank of the river Indus to about five miles upstream of Rohri.

- From three miles below Sukkur barrage head works to the village Talti in Sehwan Taluka, district Dadu, on the right bank, ground water is suitable for irrigation.

- Exactly similar to above, ground water on the left bank of the river is fresh, from three miles south of Rohri to the six miles north of Daulatpur, a settlement opposite to Talti.

- From Talti to Kotri barrage head-works, on the right bank of the river, ground water is brackish and unsuitable for irrigation.

- Although ground water in the riverain area from about six miles north of Daulatpur to six miles south of it on the left bank is brackish, but below this point to Miani forest (eleven miles north of Hyderabad) it is suitable for irrigation. Below Miani forest and up to Kotri barrage head-works, it is brackish.

- Ground water from Kotri barrage head-works down stream to the sea is brackish, throughout the riverain area on both the right and left banks, as is the case in the whole Kotri barrage command.

Provision of water for the areas having saline ground water.

This is a question most difficult to resolve and needs not only administrative mechanism for carrying out the works, but also technical and economic feasibility for success. The failures of such a system at any stage, would cause disasters, specially because the brackish water areas are continuously lying from Talti to the sea on the right bank and from the Kotri barrage head-works to the sea on the right bank and from the Kotri barrage head-works to the sea on the right bank and from the Kotri barrage head-works to the sea on both the right and left banks. They form about 50% of the riverain area. As no flood water flows down-stream of Kotri in any year for more than fifty days and in some years for only a week or so, Dhoros and river channels dry up, leading to desertification. If surface water was available, this area would also be cultivated at-least from September to June. About 50% riverain area or 750,000 acres which have fresh gro0und water under-neath, would also need water for irrigation from tube-wells, but to recharge ground water, enough flood water is needed to flow through the river Indus bed in summer for assured number of days to recharge water bearing strata's by as much as the water pumped out for irrigation in the previous season. Study of satellite imagery of riverain area shows the extent of area flooded, during the peak inundation season. The average for the last 20 years would be considered a fair amount of annual average flooding. Such area will not be brought under Kharif cultivation, but only after the floods would be put under Sailabi cultivation and one or two further irrigation dozes would be applied to the Sailabi land, to double the yields of most crops. All this needs extra water for 1.5 million acres of land in riverain area and this water needs to be calculated. Once tube-wells are installed, it would be difficult to stop farmers from pumping them in summer and rise Kharif crops.

Transportation of fresh water to the brackish water areas.

Transportation of ground water from fresh water area to brackish water area could be achieved in many ways, but these are not only costly but also difficult to handle technologically, and for which approval and considered decision of Government of Sindh will be needed. In brief it can be achieved by the following three different methods:

- Surplus water from tube-wells in riverain area can be used in the adjoining canal command areas of Sukkur barrage, and extra water so saved in Sukkur barrage areas can be passed down-stream of the Sukkur barrage to Kotri barrage. There will be resistance to it form the farmers in the tapped irrigated area. It cannot be done in case of Guddu barrage as its canals are non-perennial, but it can be done in the case of Sukkur barrage. The disadvantage in this case is heavy evaporation losses, seepage in the river channel and cost of pumping, which will make the proposal un-economical.

- An alternative to the above is that surplus ground water from Guddu and Sukkur barrages can be pumped into newly constructed channels which will run along the flood protective embankments to the next barrage, where it could be allowed to enter the barrage ponds, and from there it can be led into the new channels on down-stream side, along flood protective embankment. The flood protective embankment between New Jatoi and Daulatpur was made 85 feet wide at the top in 1974, to provide a channel in its center for soaking as well as taking water down stream. The disadvantage from it is the top-heavy cost of embankment channels besides the cost of pumping.

- Ground water in the riverain area could be pumped in to the river channel for use on down-stream side. Disadvantage of this would be absorption of a part of water in the channel banks and evaporation, and, therefore, top-heavy cost of pumping per unit of water recharging at next barrage pond. Inspite of all these difficulties, the area of 750,000 acres cannot be abandoned and solution has to be found irrespective of cost considerations and technological difficulties as the area has historical rights.

Mining of water in Riverain areas.

In practice it is possible to over-pump the riverain area or mine water to be replenished during the next floods. It does have the disadvantage of high pumping cost, movement of water from irrigated area to the reverin area and movement of this water will cause lowering of water table in the irrigated areas. As a consequence, more water will be needed for irrigation, in those areas. There is also a danger of brackish water lying underneath fresh water, to rise and thereby turn the fresh water saline. There is saline water in vast irrigated areas in Larkana and upper Dadu districts out-side the river embankments. This water will gradually move towards the river and first turn the narrow ground water belt along the Dadu canal brackish and then get into riverain areas and turn them brackish too.

Riverain area between Kotri barrage and the sea.

This area is 87 miles (140 kilometers) long as the crow flies about 10 miles (16 kilometers) wide between embankments and had some 350,000 acres of land under forest and agriculture crops in 1980. It was most productive land in Sindh and had become the leading horticultural land in Pakistan, growing bananas and melons, which were mostly for export. Water shortage had hit the area, since 1980, but periodic release of water from Kotri Barrage filled the river channel and Dhoros and pumping was a resorted from them. By 1985 there was serious water shortage, but soon afterwards, Banana Bunchy Top Virus destroyed the banana plantations in the whole Thatta district in 1988 and 1989. The same was being carried by southwestern winds. By March 1990, the disease reached the vicinity of Hyderabad. Plantations out-side riverain areas in Thatta district had also been destroyed by the disease. Due to lack of water below Kotri, the melon industry too was destroyed.

Due to lack of water in the river flowing to the sea, tide water started entering the river. The high tide is about ten feet in height and with poor slopes of land of 2 to 3 inches a mile (00035 to 0.005%), water reaches upstream of Sujawal Bridge in the bed of the river. Ground water is brackish in the whole of Thatta district but fresh water in the river kept seeping in to the adjoining areas and diluted saline ground water, which had become potable for domestic and animal use for centuries. Since 1989, however, the situation has reversed and ground water has turned highly saline due to seepage of tide water to areas both within and out-side the flood protective embankments on both sides of the river. Salts have also come up the surface and surface salinity of soils has increased, killing the previous vegetation and making land unfit for cultivation or growing natural grasses. The fallow and waste lands, which once were grazing areas, turned into non-cultivable waste lands. The people with animals there had to migrate away from all Talukas bordering the river in Thatta district. This migration caused dwindling of towns. A large town of Keti Bunder which had population of 25,000 souls was left reduced to 5,000 in past 10 years showing the overall effect of migrations and dwindling economy.

The forests in the riverian area are no more and have disappeared. Fisheries industry in riverain area has almost disappeared too. Today the meager 5,000 people in Keti Bunder, the sea shore town, are not surviving due to inland trade, but due to fishing boats form Karachi, visiting it for provisions. The inland population has decreased not only due to absence of feed for the fish and fodder for the cattle, but due to scarcity of fresh water for humans and animals, which must now be brought from irrigated areas miles away to drink. How much overall population has migrated form the area is unknown due to lack of statistics. In general the area down stream of Kotri barrage headwork's have turned into true desert and people have suffered more than in Thar and Kohistran, though this is never mentioned and given due notice.

CHAPTER 2

WATER REQUIREMENT OF CROPS IN RIVERAIN AREA.

Assumptions.

- Crop factor or water needed by plants is usually considered at 60-65% of pan-evaporation during the growing season.

- Growing season in the Central Sindh for Kharif crops is 15th April to 30th September and for Rabi crops from 1st November to 15th March being 168 and 135 days respectively and total 303 days or say 300 days a year.

- Water from tube-well can be pumped for 12 hours a day in summer and 10 hours a day in winter, only during the day light hours.

- It is assumed that there is no down time involved in repairs etc., which would be carried out in October or 15th march to 15th April when water is not required. Any other down time would be taken care of, during off-pumping hours at night.

- It is assumed that tube-well's will be one cusec discharge and any water beyond the needs of a farmer will be sold to other farmers at rates, which will be competitive in the long run.

- There is thinking that 50% of water at watercourse out-let seeps in the watercourse and the field. However for this study seepage loss has been assumed at 33% of the total water pumped and 66% utilized towards raising crop by using improved methods of water transport.

- Since crop factor is 65% of pan-evaporation and seepage of water is 33% of tube-well discharge, water applied to crops would be about 100% of value of pan-evaporation.

- Evapotranspiration from 15th April to 30th September in the Central Sindh is 59 inches or say 60 inches (1524 mm) and therefore water applied to Kharif crop including seepage and transpiration losses, would be 60 inches or 5 feet per acre in 168 days.

- Evapotranspiration from 1st November to 15th March is 17.75 inches (444.5 mm). However farmer has to apply a dose of 4 inches of water every 2 weeks and the first dose of 6 inches for planting, in all total of 30 inches or 2.5 feet or 30 inches or 760mm of water in winter. In irrigated barrage areas water could be applied every three weeks as soils retain moisture for longer period, but in riverain areas soils are light with higher percentage of sand, and irrigation dose has to be applied every two weeks. Of 30 inches of water considerable portion will seep down, but there is no alternative, as cropping pattern will not permit precision land leveling as an economic operation. WAPDA has estimated that one cusec of water can irrigate 95 acres. This is erroneous as crop factor or crop water requirement is 60-65% of pan evaporation. Tube-wells cannot be operated for more than 10 hours a day. In sprinkler or drip-irrigation water application can match exact crop water requirement but not in flood irrigation. Drip and sprinkler irrigation systems are so costly that even horticultural crops cannot be raised on them under existing price structure of agriculture commodities.

- We have suggested four doses, one every three weeks, considering that this would be practical dose regime on land not precisely leveled by laser equipment. For Sukkur barrage, planners suggested intensity of 27% Kharif and 54% Rabbi, and 19% fallow and 345 acres per cusec of water i.e., 93 acres Kharif and 186 acres Rabbi. In actual practice even by spreading water thinly, only 35 to 40% intensity was achieved in 40 years in Sukkur barrage area, where lands were better leveled. Our figure of 45 acres per cusec pumped for 10 hours makes it 108 acres if pumped for 24 hours, a figure close to that achieved in Sukkur barrage area on one cusec of water.

- Water requirement is to be based on pan-evaporation and crop-factor.

- The extra water will seep back into the ground, but it is assumed that it gets lost by evaporation from main streams, Wahurs, Dhoros and Dhoris. This dose of 4 inches can be reduced if land is precisely leveled by laser operated machine but in flood prone areas this type of leveling cannot be repeatest often and would be uneconomical.

- Each tube-well in winter will be able to pump two acre feet a day, but only 0.833 acre feet in 10 hours a day and 112.5 acre feet in 135 days of the Rabi season.

- It is assumed that very little land will be put under summer crops for want of historical water right of riverain area, though some area was under Kharif crops on wells and pond water in the past.

- Total land in riverain area out-side the active river course, Wahurs, Dhoros and Dhoris is 1.5 million acres, of which 50,000 acres is occupied by village roads etc., and balance 1,450,000 acres is forest and agriculture land, of which 450,000 is forest land.

- It is difficult and definitely uneconomical to raise forest tree on tube-well water and therefore it is assumed that on forest land also crops will be raised.

- Since ground water in 50/5 riverain area is brackish, only on 725,000 acres crops will be raised by using tube-wells. The number of tube-wells needed would be 16,111 or say 16,000 for 50% of area in which ground water is fresh.

- The 16,000 tube-wells will pump 112.5 x 16,000 acre feet of water or 1.8 MAF each year.

- This is based on 100% intensity of 50% area under fresh ground water. If intensity is increased extra water will be pumped.

- For rest of 50% area under brackish water, transportation losses will be 50% of water requirement or 0.9 MAF. Total water requirement shall be 2.7 MAF for brackish ground water area.

- Total water requirement for the whole riverain area shall be 1.8+2.7 MAF or 4.5 MAF.

- If forest department leases out the land, the policy should be to lease it out in 16 acres plots to number of small landless farmers, displaced from the riverain areas recently over a period of 20 years, and let the farmers install tube-wells accordingly. Leasing out land to big landholders and corporations will create social problems in area already infested with law and order problems.

- Tube-wells will resolve only 50% problem as the remaining 50% area which has saline ground water, will need additional 2.7 million acre feet of surface water to irrigate it.

- Water that seeps down the irrigated fields would find its way to Dhoros, Dhoris, Wahurs and river bed and would evaporate, but in the process would support fish fauna and should not be considered a loss. One advantage of this water could be that it would be rich in nutrients leached down form the fertilizers applied to the fields. One disadvantage would be that if herbicides are applied to soil, they may leach down and kill fish. Alternatives to herbicides are cheap but farmers need training. The availability of water in the Dhoros has historical rights.

- Ground water is not un-exhaustible and has to be replenished each year from the river floods. It would require substantial quality of water flowing for more than a month to recharge ground water.

- The riverain area had historical right of almost 100% flooding and thereby 100% intensity on water of the Indus. This has to be met.

- This right should not be confused with water needed to stop intrusions of sea water in the Indus Delta, for which extra water is to be provided.

- Extracting 1.8 MAF water will lower water table in fresh ground water area of 725,000 acres by about 8.275 feet, if proposity of soil is considered as 30%. There will also be seepage of water to the river channels and that may account for drop of another 7 feet. A total of 15 feet drop may be expected if riverain area is recharged every year and pumping be done only for Rabi crop only.

- 60% tube-wells will be on left bank and 40% on right bank in Guddu barrage area, but 70 and 30% respectively in Sukkur barrage area. Overall distribution can be 66.6% on left bank and 33% on right bank.

Behavior of regenerated water in autumn, winter and spring.

During autumn and early winter months, the discharge of the river at Guddu is less than the discharge at Sukkur, showing gain due to regenerated water between Guddu and Sukkur, but for the months of February to June the discharge at Guddu is more than the discharge at Sukkur, showing the absorption of water in the ground, allowing for the normal loss of evaporation from the river bed. The development of ground water is, therefore, going to affect the supplies of Sukkur and Kotri barrages and the latter could be the worst affected. Extra supplies of water are needed at Sukkur from February to June. Kotri barrage had minimum 3,000 cusecs regenerated water in March and April since its construction in 1955 down to the recent years. This historical use of water for the past 40 years cannot be ignored. It is affected because historical rights of Katcha (riverain) area are being considered and new tube-wells are being proposed for installation by WAPDA. Farmers have already installed more than 6000 tube-wells. Extra water is to be provided to replenish ground water so removed.

Size of a tube-well.

Larger the tube-well, more economical it is to own, operate and maintain. There will be quite a few farmers having sufficient land to go in for tube-wells of 3 cusecs or so, but most practical unit would be of one cusec. Larger the tube-well discharge, larger will be the area under its command and longer will the watercourses be. Larger the tube-well discharge, larger will its watercourses be and it would create conditions for excessive seepage losses from watercourses, as soils are sandy loam, having high permeability. Although bentonite is readily available at cheap rates for lining watercourses, to avoid seepage, but its economics need to be worked out. Polyester and plastic sheets are other items for lining, but exposed to sun’s infra red rays, they will crack fast. Special sheets resisting infra red rays have life of five years, but are un-economical under our price structure.

Protection of tube-wells during floods.

The tube-well structures of what-ever type i.e., centrifugal pumps into the pit, suction pumps on the ground surface, self-priming pumps on the surface, ditch pumps with vertical shaft turbine and submersible pumps or submersible motor pumps, all have to be protected from floods. The structures have also to be so designed and constructed that they are not of any cause of concern during the floods, with regard to erosion, deposition of silt in the pit, or around the pump house and inducing new channels or causing changes in the course of existing riverain channels. They are also to be such that they themselves are not damaged.

Organization for installation and maintenance of tube-wells.

The efficiency of tube-well operation would depend primarily on creation of separate tube-well installation and repairing services in private sector. Such organizations have to be created specially for the needs of the riverain areas and they have to specialize to meet special local needs. They have also to be headquartered in nearby cities to be available at short notice. Present drilling concerns are small organizations, previously installing hand pumps. They lack equipment for tube-well drilling and installation and do nothave know-how. Due to shortage of water in 2000-2002, a large number of tube-wells were installed by these parties and almost 80% thereof failed during the first year and the rest during the next twelve months.

Supply of electric power in the riverain area.

Due to periodic flooding of the riverain areas, the Irrigation Department of Sindh was very strict about any permanent structures to be built in the riverain areas and this included even the housing. Although the construction of water-storage dams and barrages on up-stream on the Indus and its tributaries has reduced the quantum of water passing on the down-streams, but this has not eliminated the danger of periodic high floods such as those occurred in 1914, 1929, 1942, 1948, 1956, 1958, 1959, 1973, 1975, and 1995. The whole of riverain area is going to get flooded, also endangering the flood protective embankments, most probably 11 to 12 times during a century by floodwater of nearly 700,000 to 1.0 million cusecs down-streams of Sukkur barrage. This is going to repeat in future.

The success of ground water development in riverain area depends upon availability of cheap power, to energize these wells. The question whether WAPDA will supply lines in the riverain areas from high voltage lines running along the flood protective embankments and with 11 K.V feeders running to various tube-wells and whether irrigation department would agree to this. It is possible to design structures for transmission of power, as well as design suitable structures to protect the transmission poles, in case of heavy floods, and these structures shall not be the cause of erosion or silt deposition to endanger changes in the course of streams within the flood protected embankments.

If this is not possible, portable engines or portable generator sets may be deployed, but they are costly and rural people are not geared to their use without appointing operators and mechanics; who, in turn will exploit the owners on repair of equipment, too difficult for the latter to understand.

Is seepage water a loss.

- Seepage is not a loss in terms of water, as it will quickly deep down into watercourses and fields and from there seep horizontally to existing river channels and its abandoned Dhoros.

- Dhoros grow fish, which need water in continuous supply until water-table falls below their bed.

- There will be seepage loss from Dhoros and the river, but it is already there in most of the years. There is extra cost of the electric power bills to be consumers by at least 35%, as tube-wells have to pump extra water for seepage, but this cannot be avoided, if irrigation is resorted to, in the riverain areas.

- Sprinkler irrigation to reduce seepage loss is too costly to be economical under Pakistan's structure of agricultural commodity prices, unless value added crops are raised and exported by the growers.

- Pumping, seepage, evaporation and evapotranspiration will create under ground storage of 1.8 million acres feet of water in fresh ground water areas. This water will come from floodwaters in the inundation season.

- The only disadvantage is higher pumping cost as that more water is pumped than is utilized by crops. The seepage water, however, is utilized for other purposes too, for example, the fisheries, which is indirect advantage to persons in that trade.

CHAPTER 3

PRESENT TUBE-WELL TECHNOLOGY, LIMITATIONS AND SOLUTIONS.

General.

The present tube-well technology in Sindh was evolved in the Bombay Presidency during the World War-I. Only three tube-wells were installed in Sindh, two at Sakrand and one at Pad-Idan in mid-twenties and early thirties. They were copy of early California tube-wells consisting of a centrifugal pump, kept at the bottom of a pit, close to the surface of water and operated through belts by a prime-mover (petrol or diesel engines), kept on the, surface of ground. When the present author started putting tube-wells in 1953, the same system was used, except brass filters in place of coir filters then used in the Punjab and U.P (India). The brass filters had slots of 1/32 inches (0.8 mm) and this size of the slot kept most sediments out. This apparently seemed to work well but a gravel pack of two to two and a half inches (51-63.5cms) was also kept out-side the filter for additional protection. The standard tube-wells as installed were about 150-200 feet deep, discharing 1.5 cusecs of water and were powered by diesel engine or directly coupled motors on mono-block pumps. Some 3,000 tube-wells were installed between 1953-1969. After the first five years of operations, failures were reported and on examination the following factors came to light:

- The discharge of tube-wells, in some case was gradually reduced form original 1.5 cusecs in 4-5 years and in 7-10 years came down to 50% of the original.

- The filters had shown clear indication of incrustation which on examination was found to be a calcium carbonate and apparently had been dissolved in water over years, but carbon dioxide had separated at the slot-opening, while water was being pumped due to pressure differential and calcium deposited. While carbon dioxide gas escaped with pumped water to atmosphere, calcium in turn absorbed oxygen and carbon dioxide and crust in form of calcium carbonate was formed. Treatment with sulphuric acid restored discharge to 74-90%, but the problem was expected to recur.

- The gravel pack in use came from Kohat and it was considered to be free of calcium carbonate, but, to be on safe side, it was replaced with material from basalt layer underlain at the Khirthar Mountains near Wado Jabal in Dadu district, with hope of reducing incrustation at the slots.

- Although 3,000 tube-wells had been installed in 16 years, but within 5 years of installation, they had started chocking up and as acid treatment was not convenient for most farmers, the only solution lay in re-drilling and re-installation in the same pit.

- Some tube-wells started turning brackish. Tube-well technology was young having been introduced by Meinzer and Tokman in 1927 and 1936 respectively, and scientific reasons for this were not known, but soon it was realized that pumping causes an inverted cone of depression at the top and to balance vacuum so created, brackish water from down under, rose up to make another vertical cone of brackish water. More saline this water was, less in rose, but many tube-wells had their quality changed within 10 years of installation. By this time, about 50% fresh ground water area of 1964 is already saline.

Tube-wells for riverian areas.

By 1974-75, the number of tube-wells in riverian area had risen to 1500 and in the terms of real prices, it was an out-come of high prices of what and cotton ever paid to the farmer since 1950 to that date. This created incentive for farmers to put tube-wells for raising wheat and cotton, though today both are un-economical to grow on tube-well water.

Many farmers were frustrated by frequent failure of choir-rope filter tube-wells, installed by private contractors in 1970s. The choir-rope tube-well had a life varying from a few weeks to a maximum of three years, but their failure would be sudden and total, un-like brass filter tube-wells, where it was gradual reduction in discharge and a fore-warning. It was still possible that acid treatment, if properly done, was an answer, but private and government drillers and engineers needed training for it. One can safely use metallic and PVC filters in place of choir rope. Recent survey has shown that in Sindh due to fine sand in water bearing strata, life of choir rope filter on the average is two years, after which time tube-wells require replacement. As coir-rope filters invariably break when pulled out, re-boring and reinstallation is done at cost of Rs.40,000 per tube-well every two years. This fact is overlooked by various agencies, governmental as well as donor. Recently World bank is promoting choir-rope tube-wells for Sindh, basing it on experience in the Punjab, where under ground water strata's have coarse sand, whereas in Sindh strata's have fine sand. To stop flow of sand inside the filter, nylon is wrapped around coir filter, stopping flow of silt and fine sand, which seal filter in a few months to two years.

The prices of slow speed diesel engines, so cheap in late 50s and 60s, went so high due to nationalization that purchasers disappeared and this indigenous industry of Pakistan collapsed. Availability of electric power in many areas for tube-wells was another factor, which came in the way of these engines. For riverain areas electric lines are not practical except near the flood protective embankments, where main line can be run just outside the flood protective embankments. Today the tube-wells in riverain area are copy of tube-wells in barrage areas. They are not at all suitable for riverain area for the following reasons:

- In the barrage area it is easy to keep the pump close to a water table and construct permanent pump housing. As there is very little fluctuation in water table year around, the pump is fitted on a permanent foundation. In the riverain area the water table keeps fluctuating and it is 5 to 15 feet below the ground just before the arrival of annual inundation. The rise of water table depends upon the level of water in the riverbed and duration of flood, which recharges ground with water. During heavy floods, water table could rise up to 15 feet on high spots and it would be difficult to raise and lower the pump with rise and fall of water table and use it for supply of water regularly, as fluctuations would occur week after week. If pump is not lowered with lowering of water table, the discharge will not be full. When water table rises, pump has to be raised by 10-15 feet in 3-5 weeks.

- The tube-well owners being aware of this situation use the tube-well for winter (Rabi) crops and remove the pump and other equipment in summer to save the equipment from submerging.

- To raise pump and install it on new foundation, it invariably needs help of a mechanic and becomes a costly affair.

- To apply water to crops, the pump has to be raised and lowered in steps of maximum three feet, as without shifting, discharge would be low and uneconomical.

- Some enterprising land owners have built a number of foundations at different levels in the pump house, and raise the pump as water table rises and lower it as water table goes down, but the task is too difficult for an ordinary farmer. Failures of the pumps due to leakage of air from many joints is common and of frequent occurrence. Tremendous amount of planning, energy, efforts and trained manpower are needed to make this system work satisfactorily, the year around.

- Some farmers play safe by keeping the pump at a safe point, so that they do not have to raise the pump out of pump house, while water table keeps raising. A series of observations have shown the draw-down in a tube-well varies between 5-8 feet for a discharge of 1.0 – 1.5 cusecs. If the pump is kept some 6 feet above the water table, its discharge reduces to 50% or even less as suction heats reaches 11 to 14 feet. The farmers playing safe and keeping the pump above water table, do not understand this difficulty and spend extra money on electric power or diesel oil for operating the tube-well through an un-practical suction head and at low discharge.

- In general the suction type centrifugal pump tube-wells have proved economic failures on account of the above defects in operating the system, in riverin areas.

- The solution of all these problems as specific to riverin area, lies in abandoning the centrifugal pumps and installing them in pits, in favour of submersible motor pumps.

Failure for tube-wells.

As discussed above, life of coir-rope filters is un-predictable and they are liable to fail any time in the mid of the growing season, thereby ruining the farmer by loss of crops. The 1/16 inches (1.6 mm) thick brass filters made in Pakistan, are too fragile and costly. Whenever a brass filter tube-well fails, it becomes too difficult to recover filters. The steel filters rust fast, due to presence of salts, organic acids and dissolved calcium carbonate in ground water. Incrustation is a serious problem with steel filters. The glass fiber filters as well as PVC filters and pipes can give assured life of ten years without replacement. The PVC filters and pipes like brass filters would probably be too fragile and not recoverable in most cases. Gravel packing of a minimum of six inches is essential to ensure long life. Gravel pack cannot be used in case of coir-rope filters. PVC pipes may not be able to stand surging action created during developing a tube-well by compressed air.

Limitations of centrifugal pumps for pumping water from Dhoros and Ditches.

Centrifugal pumps can be selected for various discharges and suction heads and can prove to be most economical. The centrifugal pump must be kept near the water level and raised or lowered as water in Dhoros rises or falls, a problem similar to that faced in centrifugal pump kept in a pit in case of a tube-well.

Solution to the problem of pumping form Dhoros.

The solution lies in using the ditch pumps. The ditch pump is a single stage, turbine pump, laid in a pipe 8-10 vertical shaft driving it and connected at top to a head, which is powered electrically or by diesel engine. It can also be submersible motor pump. The farmer is not bothered about its working and discharge, except during the flood, when he can raise it or remove it. It does not need any foundations but its efficiency of pumping is about 10-12% less than centrifugal pump in a pit, and in other words 11-13% extra cost on power for the same amount of water.

Diesel engine as prime-mover.

Slow speed diesel engines (150-300 rpm) which were selling cheap in 60s are too costly to be manufactured. They consumed more fuel per horsepower as compared modern high-speed diesel engines, which for the same power also cost much less. Imported high speed diesel engines of 12-20 H.P cost Rs. 15,000 to 25,000, and they could be utilized for the purpose.

CHAPTER 4

TYPICAL PROPOSED TUBE-WELL DESIGN OF WATER & POWER DEVELOPMENT AUTHORITY (WAPDA) FOR GUDDU-SUKKUR RIVERAIN AREAS.

The basic requirement in design of tube-wells recommended by WAPDA are:

Brick lining six inches thick, centrifugal pumps at bottom of pit mounted on wooden blocks embedded in the lining, foundations, 12 inches wide and 6 inches thick with reinforcement bars (1/2 inch diameter), wooden beam, 18 x12 inches thick, embedded in brick lining, blind pipe 6 inches diameter, bore hole 12 inches diameter gravel filter 3 inches, strainer 5 inches PVC, centaliser, bell plug and filter entrance area 15%. In case of choir rope filter, it would be wound with coir rope at constant pressure of 10 kgs pull, total depth of tube-well 110 feet and drilling by reverse rotary. In the opinion of present writer developing tube-wells with coir and PVC is not practical.

- Depth of water table close to Flood Protective Bund, 15 feet and close to river channels 5 feet.
- Draw down for pumping one cusec of water 5 feet.
- Total pumping height 15+5 = 20 feet.
- Pump efficiency 60%. Overall efficiency 54%.
- Motor efficiency 90%.
- Rabi/Kharif intensities in 1975 were: Rabi 43.3%, Kharif 6.6% and total 50%, but this is in post Tarbela period and not before 1973, when it was 86-97% Rabi and pasture in different years.
- The individual crop intensities in 1975-76.

Rabi		Khairf.	
Wheat.	22.2%	Sorghum.	1.2%
Pulses.	11.7%	Fodder.	0.7%
Rabi fodder.	6.7%	Vegetables.	0.20%
Oil seeds.	2.4%	Cotton.	4.7%

These figures are no longer valid. Data for the 29 years has not been collected.

The future projected cropping pattern according to WAPDA 1976 with and without project:

Table 4.1 Cropping pattern percentage suggested by WAPDA.

CROP	PRESENT	WITHOUT PROJECT	WITH PROJECT
Wheat.	92.	32	45
Pulses.	11.7	13	15
Fodder.	6.4 with two irrigation	4% without two irrigations.	10.4 with irrigations.
Oil seed.	2.4	4	5
Vegetables and Pulses.	0.3	1.0	2.0
Total	30.4	56.4	77.0

Kharif

Cotton.	4.7	13	23
Sorghum.	1.2	3	
Fodder.	0.7	3	3
Vegetables.	-/6.6	-/26	
GRAND TOTAL	36.6	75.4	103.4

Crop yield projections for 2001 AD (1976 projections).
Yields in riverain area usually are 50% of those in irrigated area and without project per acre in mounds are as in table below:

Table 4.2 Yield projection in mounds per acre by WAPDA.

Crop	Present	After Project
Sorghum.	8	30
Cotton.	12	30
Fodder.	250	600
Vegetables (K).	300	600
Wheat (Sailabi).	10	10
Wheat (irrigated).	20	30
Pulses.	6	14
Oil seeds.	5	15
Fodder.	50	100
Vegetables (N)		

Water requirement at watercourse head as calculated by WAPDA (1976).

In WAPDA's, 1976 report, field efficiency is calculated as 50% and water requirement at watercourse-head or tube-well is considered as twice the water requirement of crop. Our calculation of 33% seepage and crop factor of 66% is still 33% less than WAPDA's allowance. However, WAPDA's figures are unrealistic in the sense that, even though evaporation in a fortnight is less than 1.5 inches for flood irrigation, farmer must apply a four inches dose of water in the riverain area and 3 inches in barrage area. The month-wise evaporation rates for Hyderabad and Larkana are given in tables below: The tables show that evaporation at Larkana (upper Sindh) is less than at Hyderabad (lower Sindh). The average evaporation for the barrage areas of Sindh as a whole can be considered as 76 inches (1930 mm).

Table 4.3 Month-wise pan-evaporation data of Hyderabad and Larkana.
Pan Evaporation in Hyderabad.

Month	Pan Evaporation (in mm)	Pan Evaporation (in inches)
January.	25-30	1-2
February.	75-150	3-6
March.	150-175	6-7
April.	175-200	7-8
May.	250-300	10-12
June.	250-300	10-12
July.	250-300	10-12
August.	200-	8-9
September.	150-200	6-7
October.	125-150	5-6
November.	100-125	4-5
December.	50-75	2-3
ANNUAL MEAN.	2075	81

Pan Evaporation in Larkana.

January.	50-75	2-3
February.	75-100	2-4
March.	218-254	9-10
April.	203-228	8-9
May.	203-228	8-9
June.	203-228	8-9
July.	203-228	8-9
August.	127-152	5-6
September.	152-177	6-7
October.	127-152	5-6
November.	50-75	2-3
December.	25-50	1-2
ANNUAL MEAN.	190	75

POTENTIAL FOR FUTURE DEVELOPMENT.

Fresh ground water.

With the soils of riverain area being free of salinity, good drainage and reasonably good to excellent fertility, there is a substantial potential for development, provided fresh ground water for annual recharge is made available.

Inventory of existing water sources (tube-wells, and pumped Dhoros).

The exact number of existing tube-wells is not known, and is based on guess work. There are some dug-wells in addition to tube-wells which are used for lifting water. These usually are at high spots. Some Dhoros are also being utilized for pumping. An inventory of the existing sources needs to be prepared. It could help in finding out how much water is being pumped as compared to existing potential, and also the existing land use from these sources. This survey would also include the type of pumping units and prime-movers in use. The inventory will give a good picture, whether and how much ground-water is being economically or un-economically used at present.

Statistics of riverain area, Kashmor to Sukkur, total 450,000 acres.

The table below gives some data which can be useful for planning.

Table 4.3 Statistics of riverain area from Kashmor to Sukkur.

1.	Density of population according to 1972 census.	240 persons per square mile.
2.	Family size.	7 persons per family.
3.	Work force.	30% of population.
4.	SAR of soil.	2-15.
5.	pH of soil.	7.6 – 8.5.
6.	Size of a farm (average, 1976).	6.8 acres.
7.	Kharif cropping intensity.	6.7%
8.	Rabbi cropping intensity.	43.3%
9.	Total cropping intensity.	50%
10.	Yield of Sailabi crop compared with irrigated cultivation.	50%And 125% if two dozes of water applied by tube wells or pumping from Dhoros.
11.	Forest land use.	Timber, charcoal, firewood, grazing pastures for animals, shrubs for housing, baskets and etc.
12.	Dhoros, Dhoris, Wahurs and Active river. Streams about 30%.	135,000 acres.
13.	Animal husbandry (1976).	A major occupation of the past, now dwindled.
14.	Milk yield per buffalo.	4.5 liters.
15.	Lactation period.	180-300 days.
16.	Capacity of tube wells recommended by author 1 cusec and WAPDA, 1 cusec.	1 cusec.
17.	Location of tube well recommended by WAPDA.	1 mile from flood protective Bund On right bank. 2 miles from Flood protective Bund on left bank.
18.	Well spacing minimum.	1200 feet or 4 per mile in length and width on either side.
19.	Area commanded per tube well.	95 acres as Rabi crop according to WAPDA at 100% intensity; and 45 acres according this author.

20.	Practical pumping hours a day.	12 hours in summer, and in winter 10 hours a day.
21.	Pump. Housing.	Sunk pit at present, recommended by WAPDA or no pit for sub-mersible motor pumps recommended by this author.
22.	Periodic/flood loss of Kharif crop.	43% (1976 WAPDA), 5% (in 2000 according to this author).
23.	Population census reports covering the area and agriculture census.	Years 1872 to 1996. Most of Statistics are not reliable due to political interference since 1972.
24.	Fresh ground water column depth.	Maximum upto 1000 feet but mostly less than 300 feet below which water columns invariably are saline.
25.	Deposits over lying marine sediments.	Mostly Eocene rocks, near Kashmore, Sukkur-Rohri and below Sehwan.
26.	River discharge, "Gain" months.	November – January.
27.	River discharge, "Loss" months.	February – June.
28.	Ground water Map of Sindh (attached).	Prepared by author, 1963.
29.	Regeneration within embankments 1975/76 (Sukkur to Guddu).	0.34 MAF and much reduced In 2002.
30.	Climatic maps of Sindh (see below).	Prepared by author.
31.	Distribution of population between Guddu and Sukkur.	
	Left Bank.	42%
	Right Bank.	58%
32.	Infiltration rate.	Higher than in the Indus plains.
33.	Water holding capacity.	Lower than in the Indus plains.
34.	Frequency of irrigation as needed.	Higher than in the Indus plains.
35.	Seepage	Higher than the Indus plains.
36.	Forest production in million cubic feet between Guddu and Sukkur.	
	Timber.	1.2 million cubic feet.
	Fire wood.	3.7 million cubic feet.
37.	Fish vrieties.	
	Culture:	Labee Rahist, Labso Calbassu, and Calle Cute.
	Food fish:	Spp. Notoptorus, Ophicerphalus, Nathang. (They grow in loop Bunds, artificially filled with water).

CHAPTER 5

RIVERAIN AREA AS GROUND WATER BANK.

What is ground water bank?

Riverain area can be compared with a bank in which one can store surface water supplies under ground, withdraw whenever needed, and when in need of extra water than recharge, it can give over withdrawal of ground water. “Interest” is to be paid in form of extra cost of power for pumping.

Porosity of soil in the first 30 feet (9.14 meters) depth is about 15 percent, as soil is made of mixture of silt and sand. Below first 30 feet depth it is mostly sandy. Deeper one goes, sand changes from fine to medium to coarse. Its porosity of sand varies between 30 to 35 percent with average of 33 percent. Considering withdrawal from first 50 feet (15.24 meters) of fresh ground water in 50 percent of whole Riverain area is 50 percent 2.1 million acres or 1.05 million acres, and assuming that first 10 feet (3 meters) are dry, the ground water storage capacity of 1.05 million acres of fresh ground water area will be as given in table below:

Depth in feet	Porosity	Quantum of water in each 10 feet strata	Total water in each strata in MAF (million acre feet)
0-10	15	Nil	0
10-20	15	1.05x10x0.15	1.575
20-30	15	1.05x10x0.15	1.575
30-40	15	1.05x10x0.33	3.465
40-50	33	1.05x10x0.33	3.465

Total storage capacity up to 50 feet depth 10.080 OR Say 10 MAF.

Our water requirement of the whole Katcha area for cultivation is 4.5 MAF million acre feet, but evaporation will take place from Wahurs, Dhoros, Dhoris and river channels, which can also be easily calculated, but we assume that seepage from the fields to the extent of 1/3rd of total water applied will meet needs. The first 40 feet depth can yield about 6 MAF and it can meet the extra requirements if needed. This quantity of water can come from first forty feet depth and it won’t be uneconomical to pump from that depth even for conventional crops. By tapping deeper to 50 feet we can withdraw another 4.0 million acre feet for Kharif crops.

In California (USA) they have been withdrawing water from a depth of 200 feet (61 meters). It is a very costly withdrawal depth, but high irrigation efficiency, high yields of value added crops, high technology and high prices of agriculture commodities, easily pay for cost of water. Farmers have to acquire necessary technologies before we withdraw from a depth of more than 50 feet.

Deposit, withdrawal and overdraft from ground water bank of 10 million acre feet.

Depositing in the ground water bank.

Deposits will take place in form of flood water passing through the riverain areas annually, a period which will vary from as little as one week to maximum of two months in most of the years. Deposits between Guddu and Sukkur will affect discharges at Sukkur barrage, but not too badly, as river channel between Guddu and Sukkur is perennial and deposits and withdrawals will be gradual, spread over the whole year.

Deposits between Sukkur and Kotri barrages will affect discharge at Kotri barrage adversely; but it is possible that by internal arrangement, Sindh Government adjusts the share of Kotri barrage canal requirement including supply of water to Karachi.

Deposits below Kotriwill be limited to replenish water which seeps from adjoining embankments to the main channel of the river, Wahurs, Dhoros and Dhoris during the year. Since major part of river bed dries up in most of the years, deposits may account for recharging first 25 feet depth close to the main channel. Depositing will not need special area prepared for it, channels leading to it too would not involve prepared area.

Withdrawals from ground water bank.

Withdrawals have always been taking place from embankments as natural flow towards main channel, Wahurs, Dhoros and Dhoris, and could account for 15 feet depth close to flood protective embankments and 5 feet near river bed from Guddu to Kotri.

Withdrawals also take place in form of evaporation from soil surface and evapotranspiration from plants. In future, tube-well withdrawal may be the main item of 1.8 million acre feet in fresh ground water area sand more if water is transported out from fresh ground water areas or is used for Kharif crops.

Over draft from ground water bank.

Overdraft from ground water bank up to 10 MAF (million acre feet) is possible and even more can be withdrawn at rate of about 3.4 million acre feet from every 10 feet below 50 depth at extra power costs. Some day in future, this may have to be done, at least in some years. The present centrifugal pumps in pit are not suitable for such withdrawal. Deep well submersible turbine pumps or deep well submersible motor pumps are to be used. They are capital intensive, but with long life, less maintenance costs, higher and reliable discharge and less power cost per unit of water pumped they are economical and reliable in the long run. Their overall efficiency is constant. Whereas centrifugal pump efficiency can drop to 30-50 percent of original design if suction head increases.

Advantages of ground water bank compared to other storages.

Pakistan's geography makes misdistribution of water both geographically and temporarily. Most of precipitation and runoff occurs in northern parts of Pakistan in summer, whereas most of water is used in the South. Rainfall occurs in summer and does contribute to part of irrigation requirement, but no or little rains in winter occur in the south and therefore tremendous water deficient occurs. In the north rainfall is as high as 28 inches annually and in the south at Sukkur only 4 inches, against annual pan evaporation of 75 inches. The worst is southern Sindh where pan evaporation is 81 inches against rainfall of 7 inches at Hyderabad. It is obvious that in such circumstances, if surface water supplies are inadequate, they are to be supplemented with ground water by tube-wells and if these are inadequate, water mining is done at extra cost. Declining ground water levels from mining increase the cost of pumping.

Surface water development versus ground water development.

Surface water storage dams in South Asia go back to 2000 years, and such dams exist in Sri-Lanka and South India. Modern dams were built specially after 1930 when heavy earth moving and excavation machines became available. It led to “edifice mentality”, rather than most cost effective water projects. “Bigger the better”, and dams were dedicated with speeches bronze plaques and medals before local and foreign dignitaries and ambassadors. There was little consideration to the most cost effective projects. The problems started first day of their commissioning.

Ground water development in Sindh started simultaneously with construction of Mangla dam and opening of Kotri and Guddu barrages, but there was little excitement or news media attention for completion of 3000 tube-wells between 1958-1970 in Sindh then and some 200,000 tube-wells in the Punjab. Today Sindh has about 20,000 tube-wells and the Punjab more than 600,000.

For the present, we are considering unseable ground water storage in top 50 feet of soil, which is subject to withdrawal without causing too much stress on cost of pumping. Such usable storage is expected not to cause adverse conditions for water intrusion from out-side areas and land subsidence. Tube-well water withdrawals cause land subsidence by many feet and luckily for us, ground water around Sukkur-Rohri, Hyderabad-Kotri and Sehwan is brackish and not usable and without danger of subsidence of out major cities. The use of ground water including overdraft has helped in development of arid areas of the whole world.

- Advantages of ground water storage as compared with surface water storage.
- The advantage of storage of water under ground in riverain area from Guddu to Kotri barrage area:
- It costs nothing to storage or constructs the storage.
- The only cost is that of tube-wells, their maintenance and power costs.
- It won’t silt up like dams.
- There will be no evaporation losses except in case of shallow water table areas, where phreatophyle losses may take place but are negligible.
- Ground water will have uniform temperature and mineral quality.
- They do not preempt the land surface that can be useful for all other purposes.
- They are not subject to eutrophication.

- They are immune to hazards of warfare and sabotage.
- However they are subject to degradation by wastes from industry-agriculture and municipal, if these wastes are not disposed off in proper manner before entering re-charge waters.
- They do not wear out if managed properly.
- They do not disturb archaeological and cultural sites.
- They do not interfere with in stream use such as river flow from Guddu to the sea, fisheries and boat traffic.
- Storage of ground water in riverain area will be closer to the users and is not affected by earthquakes etc.

Ground water infiltration below Kotri barrage.

Ground water below Kotri barrage is brackish, but annual flooding of the river had reduced its salinity in top strata's and it was used by populace for drinking and cattle. It had also made ground water in nearly all talukas of Thatta district less saline and was similarly used. Today it has turned saline and has caused large migration of people and cattle.

Today sea water reaches inland within about 80 miles (133 kilometers) from the coast and above Sujawal Bridge and needs to be pushed back into the sea.

Tail end Barrage.

A tail-end barrage below Keti Bunder can take care of the problem of sea water intrusion. One advantage of this barrage would be that two canals running one on each right and left banks could carry water for one week to fill depressions to provide drinking water to populace and cattle, as today people otherwise have to bring drinking water from distances up to 20 miles (33.5 kilometers), and therefore animal husbandry in the area has perished. It also has affected fishing industry.

CHAPTER 6

GROUND WATER IN SINDH AND ITS POSITION IN NEAR FUTURE.

The present author published his book “Ground Water in Sindh” in 1964 and two years later Hunting’s Technical Services in their “Lower Indus Report” found and certified the ground water maps in the work were “remarkably accurate”. The work has no; yet been superseded. Since there were no tube-wells in Sindh in 1953, author used a number of ground water indicators to locate it for the benefit of general reader. These are enumerated below.

(i) The sea level rose and around 12,000 years ago it was near Multan. Around 6,000 years ago it adjusted to south of Hyderabad. Sea water seeped in the ground and we have saline water concentrations up to a depth of 1000 feet in the alluvial plains of Sindh. It was at varying depths of 20-40 feet from the surface. The river Indus had increased water discharge from about 10,000 years ago. It roamed the present Indus plains in Sindh and changed its course frequently. Its waters seeped under ground and floated above the heavy saline water of sea origin.

(ii) For interaction between fresh river water and saline ground water, much depended on level of the latter below the soil level. The fresh water column on seeping exerted pressure on seawater displacing it and once displaced the fresh water column exerted more pressure and displaced it more and more. Thus in some areas in Sindh water in Sindh water is fresh even up to 600 feet and in other areas much less. It simply depended on how long the river flowed at a particular place, and caused the saline ground water to move under.

(iii) Study of changing courses of the river Indus shows that there is no place in Sindh, even six kilometers long and six kilometers wide, which has not been visited by the river in the past 5000-6000 years.

(iv) Whenever the river abandoned its course, the under ground water started changing quality due to evaporation form surface and evapotranspiration by plants, and thus flattening out the mound of water the river had left within, finally tended its gradual mixing up with saline sea water.

(v) If the Indus had visited a site for a couple of centuries in the past 600 years, ground water was expected to be fresh, but if the river flowed in that particular area more than 600 years ago and had flowed there for less than 200 years, ground water was already saline.

(vi) In areas where saline water was within 10-20 feet of surface, like the whole area south of the line running east to west from Shaikh Bhirkio, water remained brackish.

(vii) The same was true of Jacobabad and Shahdadkot, Kamber, and Nasirabad Talukas.

(viii) Eocene hills near Kashmore, Sukkur-Rohri, Sehwan-Daulatpur and Hyderabad contain salts, which have turned water brackish even in the river bed at all these points and about 5-10 miles north and south of these places, though the river Indus has been flowing near Sukkur. Since about 1000 AD and near Hyderabad-Kotri for about 244 years.

(ix) Water below Sehwan to Kotri is brackish as Western hills specially Manchar series are impregnated with salts and seepage of rain water from them to the river makes water brackish even in bed of the river Indus.

(x) Below Kotri barrage to the sea, water is saline in the whole area including the river bed due to simple reason that saline water table has remained within 10 to 15 feet of ground. Only shallow dug wells and hand pumps have supplied slightly brackish water, which the people use for drinking purposes and for cattle, though by all standards it is not potable.

(xi) Ground water in the central alluvial plains is fresh within 10-15 miles (16-24 kilometers) of the bed of the river, where the river has wandered during the past 600-700 years.

(xii) This fresh ground water 80-600 feet deep is underlain by the original saline water of the sea which causes serious problems. When a tube-well installed in fresh water aquifer is pumped, an inverted cone is formed above the point of maximum draw-down, i.e., tube-well pipe, and a vacuum is created by suction pressure of the pump. This vacuum is to be counter balanced in some way. Since saline water below fresh water is heavier it rises in fresh water zone forming vertical cone. This continues every time tube-well is pumped and gradually fresh water tube-well turns saline. If fresh water strata above saline water is 350 feet and if tube-well is 200 feet, discharge is two cusecs, and draw down 15 feet, it may take 30,000 to 40,000 hours of pumping to turn it brackish. Many private tube-wells have turned brackish by this process in the past forty years, but individual complaints are never recorded and data is not available.

(xiii) Solution to the problem is scavenger tube-wells, in which saline water forming a cone down below is pumped out simultaneously with fresh water being pumped out form the upper strata. It has worked satisfactorily and to retain ground water fresh, scavenger tube-wells have to be installed with every fresh water tube well, and pumped simultaneously. It increases cost of construction and power, but without it, we will have no sweet water in Sindh, within a few years.

(xiv) Tube-wells are not run even for 8 hours a day. Of the 17,000 tube wells in Sindh, 13,000 are privately owned having usual capacity of half to one cusecs, and 4,000 are government tube wells having average capacity of two cusecs. In the year 2000 to 2002 electric power was available for almost the whole day and night, and water shortage was so acute, that such tube wells were run 24 hours from December 1999 to this day. Water table in such area dropped by 15 feet or more and all the centrifugal pumps had to be lowered to bring them close to water table.

(xv) The recharge source of water removed by tube wells is irrigation water applied to the fields. Unfortunately water allowance in Sindh is so small that the farmer has to spread water thinly in summer, when actually no seepage takes place. The seepage does take place in winter. In summer salt builds up in the soil and it is drained down by excess irrigation water in winter. This water drains all salts accumulated in the soil in summer to water table. The average salinity of drained water over years may have grown to 2000 PPM. Over some years in the future, this process is going to make the total ground water in Sindh unfit for cultivation. To maintain the existing amount of intensity of cropping in Sindh, extra fresh water equivalent to presently pumped quantity is needed from the river sources.

CHAPTER 7

SCHEMES OF GOVERNMENT FOR INSTALLATION OF TUBE-WELLS IN SINDH AND SOME SUGGESTIONS IN THAT BEHALF.

There are schemes to install some tube-wells in Sindh at subsidized rates, the government contributing 50% of the cost. There were subsidized tube-well schmeds installed from 1957/58 to 1969/70, under which a large number of tube-wells installed for the first time in Sindh. Irrespective of the amount of subsidy, the following were the guidelines:

- Tube wells will be drilled by the department of Agriculture.
- Filters, pipes, bends, sockets and foot-valves will be supplied by the department.
- Pipes used would be according to British standard specifications or equivalent American, Japanese and German standards (ASTM; JI, Din standards).
- Brass filters were to be used.
- Annular space between tube-well filters and drilling pipe was to be filled with graded gravel from Kohat, Hindu Bagh or Nagar Parker; being free from carbonates. Use of coir rope filter and wrapping them with nylon was not permitted.
- The grower had choice to buy engines, motors, pumps from three manufacturers, for example, engines from BECO, Ittefaq and Hussains, electric pumping sets from BECO and KSB and pumps with bends, sockets and foot-valves from BECO, Ittefaq and KSB.
- Annual rate contractor were issued and supplier’s prices were fixed.
- A number of engines and pumps were stocked and orders placed when needed.
- Growers, who had to pay part of cost, could select any equipment, the cheapest or costliest.
- Anticipated life of tube-well was 10 years, though some lasted longer.
- Filters allowed fine sand and silt to pass through the gravel pack and filter slots and it did not cement the filter, as was done by coir rope filters or coir filters or coir-rope filters wrapped with nylon.

- The growers deposited their share of money in advance.

- By 1962, district wise maps of ground water, its quality and depth were available from writings of the present writer and it became easy to know if fresh ground water was available at the applicant’s land. In case of marginal areas, drilling was done at risk of the grower and if water turned out to be fresh, tube well was installed at subsidized rates.

- Soil and water samples were invariably tested for every 10 feet depth and only most suitable sites were selected. In marginal areas any grower could put a tube-well at his own cost and department cooperated fully, but no subsidized tube-wells were installed.

- Drilling charges were fixed by the department and growers paid these.

- Growers supplied labor, but as farm labor proved very inefficient labour was organized by drillers and growers paid for it.

- Tube-wells were kept as deep as possible and filter length of 100 feet was common in majority of cases, but growers had choice to reduce it to 60 feet if tube-well was not too deep.

- Common discharge of pump was 1.5 cusecs but some pumps of 2.0 or 1.25 cusecs were also installed.

- Cost difference between 1.25m 1.5 and 2.0 cusecs tube-wells was small, but depth determined overall cost.

- Drilling by private drillers for subsidized tube-wells was disallowed as they did not have capacity to drill deep and 10 or 12 inches bores for gravel packing. Their charges were high and they spoiled quality of workmanship.

- The department had 65 hand drilling rigs and also 6 power rigs in Sindh, but the latter were used in Thar and Kohistan.

- The department installed an average of 250 tube-wells a year, with 65 hand rigs.

- The progress could have been double of this, but trained drilling mechanics to install engines and pumps were lacking. However grower’s demand was fully met and increased year after year.

- Pump house including pumping pit was constructed by the growers but pump and engine foundations were installed by the department.

- The department installed and started a tube-well and by periodic visits to the site, monitored the tube-well for some years.

Tube wells installed by private parties were shallow. Some of these failed to pump water on the very first day of starting and many failed during the first year. At the best their life was 3 years, when redrilling and putting new filters was needed. Most of failures were attributed to cementing of filters due to wrappings with nylon or sand cutting holes in the coir rope. Since the depth of tube-wells was shallow, there was more draw-down, and power requirement per unit of water pumped was nearly double. On failure of these wells, growers came to department, which being well informed, did not repeat mistakes of private drillers.

Private drillers did not test water samples. Many times they put in tube-wells in marginal or saline areas. The high pH and high salinity tube-wells spoiled the land and its fertility. It was known that the grower would take years to reclaim such lands and cost-benefit ratio of reclamation will be poor.

After 1970s the department gradually lost its capacity to install tube-wells, and private drillers took over. As usual some of their tube-wells failed to pump water to start with, and others went out of order in 2-3 years. Their discharge became low within 6 months, due to segmentation and power cost per unit of water pumped became exorbitant. In view of this the following are suggestions for new schemes of the government.

i) Work may be got done by private drillers who have facilities to install diameter and have necessary staff and equipment. About 20 such contractors or even more may be enlisted. Each driller is to have capacity to install a minimum of one tube-well a month and number of pre-qualified drillers may be adjusted accordingly. The growers can use any driller of their choice.

ii) Growers may be asked to apply for tube-wells and only areas having fresh water of less than 900-ppm salinity may be selected for tube-well installation.

iii) There should be no compromise on depth of tube-well, diameter of filters and ppm salt content.

iv) Better type of filters may be used. Fiber glass of PVC filters are now commonly used by many government agencies. Their economic life may be compared with nylon wrapped coir-rope filters and cost effectiveness determined accordingly.

v) Economic of various types and sizes of tube-wells may be studied.

vi) Feasibility of tube-wells in different areas for different crops may be studied to find out justification of installation of tube-wells in each area and its cropping pattern.

vii) Most economic size of tube well may be found out. Since growers sell water for which there is high demand by neighboring farmers, tube-wells of larger size may be feasible in spite of small land holdings of growers.

viii) Since department does not have expertise, consultants are to be engaged to work out the following:

1. Earmark areas of good water quality below 900-ppm salts and also suggest the depth of tube-wells.
2. Suggest filter type, diameter, length and depth, gravel pak size, blind pipe length and diameter, pump size and discharge and power needed for the motor. Suggest correct size motor for the pump.
3. Pump house for post draught ground water depth of 20 feet or more may cost more than Rs.100,000 and may make submersible motor pump more cost effective. This may be studied and where possible the system may be tried if growers can afford it.
4. Study present filters and suggest the best types, having life of not less than 10 years.
5. Help in selection of contractors.
6. Prepare designs, bill of quantities (BOQ) and cost estimates of the whole project.
7. Supervise work of drilling, tube well installation and development and its initial operation. Prepare standard specifications for use of department and contractors.
8. Supervise work of drilling, installation and initial operation by contractors.
9. The department will send for applications of pre-qualification of drillers and the drilling rates. Consultants will examine the applications, visit premises of drillers, recommend the names of suitable candidates and advise on rates. The department will negotiate rates with drillers and bring down rates as recommended by consultants.
10. Department may or may not accept any recommendation of the consultants for reasons to be put in writing.
11. Department will send for tenders for equipment, the specifications of which will be prepared by the consultants and issue rate contracts after rate analysis by the consultants. Attempt would be made to select at least three manufacturers of repute for each piece of equipment.
12. The drilling contractor would drill, take out samples of water at every 10 feet depth and send it for testing at two different laboratories approved by the department.
13. Depending on the quality tests and coarseness of sand, consultants will recommend filter type, size and length and gravel pack size.

14. Separate contractors will be engaged for supply of gravel, which is free of carbonates, which are responsible for cementing of filters.
15. Contractors may be engaged for transport of materials to the site.
16. Drilling contractors will also install tube-well, properly center the filters and pipes and gravel pack the filter. They will install engine, motor pump and start the tube-well when power is supplied. All these will be done according to specifications prepared by consultants.
17. Consultants will certify bills of contractors after inspection and satisfaction at different stages of work for which payment schedule will be worked out by consultants. Part payments to be extent of 75% of bills will be allowed and balance 25% released on completion of individual tube-well.
18. Contractors will deposit earnest money to the extent of 10% of contract value and this shall be refunded only after the entire work has been fully completed and satisfactorily checked and certified by the consultants.
19. Engaging of consultants will ensure that no subsidy is given to people on existing tube-wells.

CHAPTER 8

LINING OF CANALS AND WATERCOURSES. (Government Proposals).

Author has worked for 100 months as consultant to L.B.O.D (On Farm Water Management Project) of lining about 30% length of 1450 watercourses, and found that much publicized 30 to 40% watercourse losses without lining is not applicable to Sindh conditions. Water losses due to seepage from watercourses account for not more than 5%, whereas leakage losses can amount to 30%. Leakages occur due to breaches enroute in idle run of a watercourse; it over flows to other lands or suffers frequent breaches at its inlets to the fields. In spite of proper gradient, very fine silt deposit takes place in a watercourse due to various causes, and mainly due to silt depositing at some points. Landowners fail to maintain embankments causing leakages. Seepage to the ground from watercourses in Sindh is negligible, as fine clay in suspension in water which some times reaches even six parts per thousand parts by volume, deposits in the bed of watercourses and seals the bottom against seepage. If during silt clearance this layer is removed, seepage does take place. The only advantage of lining watercourses is that the bed of a watercourse has proper depth and gradient. Silt clearance is easy and cheap, but is not eliminated altogether. Seepage did take place from all new canals in Sukkur and other barrage canals in the borrow pits, after their construction for a few years, but after some years they dried up except, where they flowed through sandy portions. Author had put in a number of tube wells in Rohri Canal command area in early 60s below Sakrand Regulator and found water table very deep at the depth of 15-20 feet next to this canal and for further ten years this depth remained constant, showing no seepage, as by that date silt layer at the bottom of the canal was quite thick and the borrow pits were also dry for years together. After construction of Tarbela Dam, extra water available to Sindh was not diverted for new areas by new canals, as was and is being done in the Punjab. But in Sindh old canals were made to carry extra water, which was distributed among the farmers. As an example Rohri Canal was made to carry 16,000 cusecs, instead of its original 1932 design of 9,600 cusecs. Extra water was put in various watercourses and from 1975, water table started rising fast and in just five years rose from 22 feet to just 6-7 feet, adjoining its embankments near Khesano Mori of Rohri and, as extra water applied above the evapotranspiration requirements of plants, simply seeped into ground, raising water table up by 3 feet a year. Water from fields and not canals seeped into borrow pit filling them up for the first time, at least in 25 years and during the present drought one has to dig at least 8 feet below the bed of borrow pits to reach water table, clearly showing that no seepage is taking place from canal. Installation of piezometers along the various canals and also some distance away from their embankments along Rohri canal also will show if the claim of seepage from canals is correct or not. The lining of watercourses first introduced by USAID in mid seventies was based on seepage from watercourses in sandy and rocky areas of other countries. No experimental work was done in Sindh and where lining has been done on large scale as in the L.B.O.D project. Lining has neither increased area under crops, nor has increased the intensity of cropping, proving thereby futility of this theory in Sindh. Seepage from canals would be serious problem in Baluchistan and NWFP's rocky and sandy soils.

The Punjab soils being light and with predominantly sandy or silty soils, there would be seepage problems there, but in Sindh the story is totally different.

The supporters of lining have started theorizing that if water carries very fine silt (or clay) sealing the canals and water course beds the same fine particles can also seal our soils and nothing can grow. They little realize that a watercourse having bed width of 1.5 to 2.0 feet and about 2 miles long irrigating 500 acres has wetted area of about 0.5 acres. The fine silt deposited in its bottom in one year and sealing it will take 1000 years to seal 500 acres and this has already been taking place not only in Sindh but also in the Punjab for the past 10,000 years and this very fine silt has deposited at depth of 30 to 50 inches below the soil in form of hard pan, which is clay and brick layers and potters have been extracting it from that depth. The mud houses are also made from the same material called clay.

Newly constructed Jamrao canal will definitely have the seepage problem for some years, while fine clay particles in time will seal the space between the slit particles at its bed. The present assumption of 30% losses is not based on experimental results but general propaganda of past 25 years of the post-Tarbela extra water which has caused water logging. It needs to be verified by actual trials and use of radio isotopes, and aid-giving agencies have to probe into it, in case of Sindh.

There is also another fond theory developed recently that seepage water from newly constructed canals to borrow pits, may be pumped back into the canals to save this water. Pumping from borrow pits will induce more seepage to them from canals, and movement of fine clay particles towards pumping point from below the bottom of canals and embankments, will induce more seepage. Ultimately embankments will collapse. And this very thing is happening for the past two years with no scientific study to halt it.

For watercourse lining in Sindh, the author suggests lining of two-meter length at every 50 meters, so that the bed level is accurately fixed and such points become reference points for silt clearance crew. However each one or two acres of land should be given a separate outlet (Nuka) and check structure, to ensure that no leakage takes place at these points of common failures. The canals need not be lined. The present belief of seepage from canals in Sindh has never been investigated scientifically and is only a guesswork.

It is not realized that enormous quantities of water seep down to the water table from the field. Pan-evaporation in the central Sindh in the months of October to March the average is 150, 63, 37, 63, 85 and 158 mm. Farmers usually apply two irrigation doses of about 100 mm every fortnight and 200 mm in each month. It is obvious that extra water applied to the field above pan-evaporation will seep into ground and water table will rise. Comparatively there is less seepage from fields in summer than in winter but only few people know it. No attention is paid to precision in land leveling to reduce irrigation dose from present average of 100 mm to say 50-63 mm. There prevails general ignorance about seepage from the fields, and canals are blamed for it. This needs a thorough scientific investigation.