SEEPAGE OF WATER FROM THE RIVER INDUS AND OCCURRENCE OF FRESH GROUND WATER IN SINDH

BY
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I was involved with investigation of ground water in the Province of Sindh since 1953, with the first assignment as Agricultural Engineer in Sindh. My previous experience in various areas of Sindh had revealed that in many cases even at shallow depths of a few meters, ground water was brackish in the Indus plains of Sindh. The easiest solution for the initial ground water survey was to take samples out from the existing dug and lined wells which were about 10 meters deep and also from hand pumps of same depth used for domestic purposes. Such wells and hand pumps existed in each one of some 20,000 sizeable villages in the Indus Alluvial Plains. A representative survey of about 2,000 such water sources showed that ground water in the close vicinity of the river Indus was invariably fresh, in the first 280 miles of its run in Sindh from Kashmore to Hyderabad, but was slightly brackish on the down streams side up to the point, where it discharged into the Arabian sea. This general rule did not apply to whole Sindh as there were areas, even 40 miles away from the river Indus, which also had fresh water. I therefore thought that the river Indus which has been changing courses periodically had passed through such areas in the recent centuries and seepage from it has left fresh water there. It appeared that, if I could get correct information on the courses of the river Indus in the past, the occurrence and the quality of ground water could probably be known comparatively more reliably. Luckily I had already come across three classical books of Raverty, Haig and Cousens which had discussed the ancient courses of river Indus and also had left some maps (18, 13, 38). Reviewing this literature and also some geographical writing of Pithawalla (34, 35, 36 and 37). I concluded that information in them was scanty for my purposes and old courses of river Indus had to be traced on the ground and dated I started the search.

While traveling on the various roads in Sindh, which in its Indus Alluvial Plains is flat slopping from north to south towards the sea, I found depressions in the roads a kilometer or part of it in length or a series of depressions each only a few hundred meters long, separated by one or two hundred meters of normal level ground. The depth of these depressions was only one meter to three meters in most of the cases. Standing at the edge of the any depression, I found that it continues on both sides as the human eye can see and seemed to continue many miles inland. It struck to me that these were the old beds of the river Indus and I tried to prepare a map of all such depressions. More than 90% these depressions were not under crops in early 1950's and natural vegetation in them was slightly distinct from the adjoining high level land, being thicker in plant population and deeper in color. Even where depressions were cultivated the vegetation had a slightly deeper green color showing fertility of soils newly brought under cultivation after

centuries. In the same year aerial photography of whole Pakistan was started by the Canadians under Colombo Plan, but these photographs were not available to me until 12 years later and therefore I thought of viewing the courses of river from the air and marking them on the map. I had a friend, a Senior Captain in Pakistan International Airlines, which had daily flights from Karachi to Lahore, Islamabad, Quetta and etc. With his help, any flight I took to above 3 destinations, PIA crew provided with me a route maps and exact location over which we were flying any time. They also allowed me to enter in cook-pit to carryout by work. I took 4 return trips each month fro 2 years and prepared a number of maps as an outcome of this help. I also dabbled into archaeology, to date the various courses. The shade of the courses as viewed from 20,000 feet heights of the planes also gave some indication of antiquity of the courses, however defective.

I compiled all this information on a map 1:250,000 (1 inch equal to about ½ mile). Archaeology had already given me an insight into the antiquity of ruined settlements and the years of their prosperity. Further study of the geology of the area and sea level changes had shown that the Arabian sea was closer to Hyderabad some 10,000 to 12,000 years ago than at the present, when it is 80 miles away from this city and therefore the river Indus had not flowed enough centuries through this deltaic area to convert saline water into fresh ones (14 and 15). Viewing the situation as thus, I came to the following general conclusions:

- The present course of the river Indus was established 236 years ago in 1758/59 and has shifted only couple of miles from its central coarse towards its right or left (13, 18, 28 and 29).

- The British started putting levees (embankments) at the distance of approximately 5 miles (8 km) on either side of the river Indus from 1859 and over next 50-60 years Levees were built from Guddu Head Works to the Arabian Sea (15 and 16). The river was thus confined within this width 10 miles.

- As a consequence of levees ground water within the protective embankments is fresh in most of the area from Kashmore to Hyderabad with following few exceptions (26, 27, 28, 29 and 30).

    - Shewan to Kotri on the right Bank due to seepage of saline water form the Khirthar Hills to the river (2 and 4).

    - Close vicinity of Kashmore and Sukkur on the same bank due to seepage of saline water to the river from Bhugti Hils. (2 and 4).

    - Near Sukkur and Rohri on both bank of river due to seepage brackish water from Eocene Series of Kot Dijji Hills. (2 and 3).

The sweet water belt on the right bank of the river Indus is more than 30 miles wide near Sukkur and narrows down only to a few miles as one comes closer to Sehwan. This is due

to presence of brackish water of the Khirthar hills between Shahdadkot and Sehwan, moving towards the river.

On the left bank, width of fresh water zone varies between 30-40 miles from Guddu Barrage Head Works to Hyderabad, where it narrows down to about 20 miles width. It is also narrow near Sukkur Rohri due to presence of Eocene Series of hills.

These initial investigations did not give clue to the depth of fresh water and its quality for irrigational purposes. Since the various courses of river Indus had already been marked on a map and many of them could also be dated from archaeological evidence, it was concluded that a few test bores scattered all over the area marked as shallow sweet water zone, will give clue to anticipated depth of fresh water. Again as luck would have the Government in 1958 encouraged drilling private tube wells for the farmers by Agricultural Engineering Section, at highly subsidized rates and also installation of complete tube-wells payable in 10 years without interest. This gave me an opportunity to put scattered bores all over this area. Between 1958 and 1962 one thousand test bores about 150-200 feet deep were drilled and data gave a picture of deep fresh water areas. The shallow fresh water areas from which water samples were collected in 1953-1955, was now divided into two separate zones, "shallow" and "deep". Prior to 1958, only 6 tube-wells having depth of less than 100 feet existed in the whole Sindh. Location of deep fresh water gave an impetus to installation of tube-wells in the deep fresh water zone. In next 10 years 2,000 tube-wells were installed in whole Sindh for irrigational purposes, as it was no longer necessary to put in to test bore first, then install tube-wells.

Putting of test bores also lead to co-relation between the ancient courses of river Indus, their age, duration of flow and occurrence of fresh water. It was found (28, 29 and 30) that:

- Fresh water invariably occurred in areas where river had its courses for a few centuries during the past 800 years.

- In the areas where river courses existed during the past 1500 years water was fresh only between Guddu and Sehwan and not South of Sehwan.

- Between Sehwan and Hyderabad water had turn brackish, where ever river was present between 500-1200 AD, or earlier but not after 1200 AD.

- In the areas ground water was brackish, chloride content was much higher than carbonates and bi-carbonates, indicating that some millennia ago, area was submerged into sea water and though meandering of the river Indus had diluted brackish water, but 800 years of deserting by the Indus had allowed saline water down below to displace fresh water by various process of encroachment, surface evaporation and dilution (28 and 29). In fact the fresh water seeped from the Indus was simply floating on saline sea water down below, like ice floats in water due to different specific gravities.

- Between Tando Mohd Khan and Bulri where river was consistently flowing between 13th to 18th centuries, now fresh water is present in shallow depth about 50-60 feet. This exception for areas South of Hyderabad can be accounted for, by the fact that most probably a branch of the river Indus, passed through the same location to Barbarican or Bambhore since about 200 BC – 1758 AD (13, 17, 18, 29, 31, 32 and 34).

- Shallow fresh water is present along the old course of river Indus known as Eastern Puran from Mirpurkhas down to vicinity to Kadhan, because in this portion, passed the "Lost river of the Great South Asian Desert", now called Drishadvati/Sarsuti/Hakra (17-20, 22-24, 33-35, 40-47). Through waters of this river started reducing since 2000 AD, but over flows from the Sutlej and Indus, on up-stream side of Sukkur contributed some water each year and also an eastern branch of the river Indus passed through the lower portion of this river form Mirpurkhas to Kori Creek. Presence of water in this branch almost annually since 2000 BC to 1762 AD has retained shallow fresh ground water in that area.

Behavior of the Indus.

- Indus erodes the soils in its upper reaches and carries large quantities of silt with it in suspension. Silt load varies with its velocity, being less at low velocities.

- A silt load of 0.6% or 6 parts per 1000 parts of water has been recorded.

- On reaching Sindh border, velocity of water decreases due to low gradient of less than 8" to a mile, or 12.62 cm/kilometer, or .0126%.

- At this slope velocity decreases sufficiently enough, to deposit silt in the bed of the river.

- Maximum silt deposition occurs at the outer edges of the stream due to lowest velocities and minimum at the centre of stream, where velocities are more.

- Deposition of silt at the edges raises ground level reduces velocities further and more silt deposit, forming embankments.

- The river thus forms its own embankments, within which it flows for many years, raising it-self above the adjoining plains by many meters.

- One day during high flood it breaches its embankment and flows in the depression from which it does not come out until it has raised its level, above the surroundings.

- Minor breaches occur very frequently and some important minor changes have even caused abandoning of some settlements and cultivated lands.

- Major breaches called major changes in the course of the river have occurred every century or two. Such major changes have caused abandoning of up to a million acres of cultivated land and migration of more than a million people.

- Every change in the course of the river has invariably caused down fall of the ruling dynasty of the time.

A few such changes in the ruling dynasties or Government occurred in the following years (1, 7, 8, 9, 10, 18, 19, 21, 31, 33, 35 and 42).

YEAR	CHANGE OF GOVERNMENT
400 BC or afterwards.	Achaemnian lost control over Sindh and new kingdoms namely Musicanus, Sambus, Oxycanus and Moeris, established. They had to face Alexander in 326-324 BC. The river still not stable; Mauryans consolidated their power when river stabilized.
River unstable between 2nd century BC, and end of 3rd century AD.	Fall of various dynasties of Sindh and frequent change of rulers.
400-700 AD.	River stable and peaceful rule of Vahlikas, Rais, and Brahmans.
700 AD.	River changes course in southern Sindh, which turned into waste and Arabs easily defeated Dahar.
714-854 AD.	Arab governors were not able to restore irrigation canals resulting into civil war which continue up to 854 AD, when Habaris threw out Arab governors.
854-1011 AD.	River stable, Habaris promoted canal irrigation and ruled with prosperity.
1011-1333 AD.	River changed course around 1040, 1250 and 1333 AD. Each change brought new Soomra dynasty and last charge brought Summas in power.
1333-1525 AD.	River stable and peaceful rule of Sammas.
1525-1700 AD.	River stable but with low discharge due to Little Ice Age and civil war in Sindh for 175 years.
1700-1758 AD.	River stable, warming increased river flow, new canal established and glory of the Kalhora rule.
1758 AD.	River changes course and civil war stars Kalhoras replaced by Talpur.
1843-1947 AD.	River made stable by constructing of levees (embankments), confining the river in 10 miles width by the British. Province becomes prosperous.
1947-1994 AD	Construction of many Barrages and dams on the Indus and its tributaries. The Indus flows to the seas only for 2 months a year and the environments within flood protective embankments start deteriorating, Through out its length of 350 miles.

Shifting of Settlements.

Because of changes in the course of the river Indus and continuous deposit of silt in the Indus Plains average rise in the level of the alluvial plains settlements once abandoned are buried under silt. Even if not silted for some time, settlements do not survive because of lack of water for irrigation and cultivation and also because of the existence of brackish ground water, unfit for human and cattle use. Where is ground water is fresh a settlement in decayed state may continue for some time, but without economic support of cultivation around, it dwindles to insignificance and in times to come becomes lower than surroundings and one day is flooded by the river water, silted and buried. There are a few settlements, which have survived during the past centuries due to their advantageous location under which, flooding and silting has not been possible. Such settlements are:

- **Sehwan:** This city lies above the level of river Indus and at the foot of the hills. River has not eroded it because, Aral canal which carries discharge water of Manchar Lake (which in turn has carries combined water of the Gaj, the Bolan and other rain-feed streams) to the river almost each year in July-August monsoons, erodes its opposite bank and thereby making the river not to erode the right bank on which stands Sehwan town.

- The town of Sann stands on the western branch of the Indus, but town has survived the erosion action of the Indus for a few hundreds of years. It can not westward, even by a few feet as the Sann a rain-fed river discharging in the river Indus near this town, erodes its opposite bank and pushes the Indus waters away. When the Sann River discharges rain water, the grey waters of the Indus are visible only on the eastern bank; the western bank has yellowish waters of the San River.

- Almost similar is the action of the Baran on the Indus, near Ongar and thanks to Baran that the town of Jherruck has survived the erosion of the Indus for 2000 years.

- Rain feed streams, Red and Kalu are responsible for maintaining Kinjhar Lake which depression, they eroded before entering the Indus. Town of Jhimpir on Kinjhar was first recorded by Arabs in 711 AD, but may be much older.

- Junghshahi River did the same and created Kalri and Haleji lakes depressions before discharging in the western branches of the Indus. It appears that heavy discharge of Junghshahi streams in the 13th century changed course of Kalri Branch, causing decay of Bhambhore soon after its burning by Khawarism Shah in 1226 AD.

The Indus River Gorges.

River gorges have played the role of fixing a river at point. The river Indus has passed through number of gorges in Sindh through its recent history of 2500 years. The towns

establish on both banks of the gorges usually survived for many centuries. The following are the examples:

- Alore – Sukkur-Rohri gorges. Two small gorges near Sukkur and Alore have existed probably for more than 2,500 years. Important towns of Alore, Rohri, and Sukkur existed on these two gorges. Sukkur described as Sakara by Panini the grammarian (525-475 BC), stood on the right bank of the Indus. Ruruka is described a town in the same vicinity and probably is Alore or Rohri. Alore which has survived as a small settlement on the river gorge was once the capital city of Sindh and probably capital of Musicanus, who was defeated and killed by Alexander in 325 BC. Between 950-1050 AD, the Sukkur gorge become wider and deeper and carried most of the waters of the river Indus and thus drying up Alore gorge and bringing an end to its glorious days. Subsequently the Sukkur gorge widened further and bi-furcating into two, leaving three islands in between. These three were subsequently occupied by a military fort called Bakhar and two shrines called "Sadh Bala" and "Zindhah Pir". As late as 17th century the gorge on the Sukkur side was shallow and with projecting shoals which damaged many wooden hoats. During the next two centuries, its depth has increased further. ("Tarikh-i-Mazahar Shah Jehani – Persian").

- Samui and Bhambhore gorges. Another two small gorges which were responsible for survival of Bambhore or Barbarican or Debal were; Samui gorge north of Makli hills on the present Thatta-Jungshahi road and a gorge between Bambhore it-self and small hillock on the opposite side. Bambhore has survived from about 200 BC to about 1300 AD, when a major change in the course of the river Indus in the middle Sindh, established the main course of the river Indus through Uderolal, Nasarpur, Shaikh Birkhio, Tando Mohd Khan and Badin. A western branch of the river established it-self to the south side of present town of Thatta. Both Banbhore and Sumai decayed. Though Banbhore was burnt and looted in 1226 AD, by Khawarism Shah, yet its name as Debal survived for a century to be replaced by an important port namely Lahri Bunder before 1333 AD.

Human Settlements.

- Amri 3770 BC – 3370 BC Amri is the only important site belonging to this era and the number of other contemporary sites lay buried under the ground.
- Kot Dijji 3370-2300 BC. Kot Dijji and contemporary sites. Kot Dijji existed not on the main river but on the branch passing through Alore gorge, which carried part of the water of the Indus.

Mature Indus Sites 2300 BC – 1650 BC.

There are represented by the Mohenjo Daro and are categorized as a Mature Indus Culture sites, being present at the following places, on the branches of the Indus:

- Jundier jo Daro (on Bolan Manchar drainage in Baluchistan) and Lime jo Daro (on the Western Branch of the Indus).

- Vinjrot (on Drishadvati – Sarsuti – Hakra System).

- Mohenjo Daro, Jhukar, Lohan-jo-Daro, Chanhu Daro, in the northern Sindh (on the main branch of the river Indus).

- Pandhi Wahi, Ali Murad, Tando Rahim Khan, Ghazi Shah, Shah Hassan, Sehwan and Amri (on Bolan-Manchar-Aral Drainage System).

- Pokran, Taung, Khajir, Shah-jo-Kotrio, Arab-jo-Thano, Osman Buthi, Jhangari and Diso, (on the Baran a rain fed tributary of the Indus).

- Nohot (on Drishadvati – Sarsuti – Hakra and eastern branch of the Indus).

- A number of un-surveyed sites exist along the Raini-Hakra (Drishadvati-Sarsuti) in Sukkur and Khairpur districts.

Declining Indus Culture:

- Jhukar (on the Indus).

- Jhangar (on the Manchar Lake).

Settlements in Sindh 500 BC to 200 BC.

- Alore (on Alore Gorge on the eastern branch of the Indus and capital of Musicanus).

- Mahota (on the main branch of the Indus).

- Pattala (Brahmanabad), mentioned as Brahmanka, in Panini's grammar of Sanskrit language) stood on the eastern branch of the Indus.

- Sukkur (known as Sakara to Panini) stood on the western side of a gorge on the Indus.

- Alexnader's Heaven (Bhanbhore or Barbarican) on the western deltaic branch of the Indus.

- Sehwan on Aral branch of Bolan-Manchar Aral drain.

Settlements in Sindh 200 BC to 100 AD.

- Alore (on Alore Gorge of the Indus).

- Sadoman (Sehwan) on Aral branch of the Indus.
- Minnagara or (Patala or Binagara), on deltaic, branch of the Indus.
- Barbarican (Banbhore) on the deltaic, western branch of the Indus.
- Ranikot fort was built 35 miles west of the course of the Indus, for protection against land river invasion.

100 AD to 750 AD. Settlement on the western branch of the Indus and Bolan-Manchar Aral drainage:

- Limu-jo-Daro, Lala-ji-Mari, Pandhi Wahi, Sisam (Shah Hassan), Tando Rahim, Ghazi Shah, Ali Murad, Sehwan, Dhamraho and Mahota.
- Towns on the eastern branch of the Indus, passing through Alore Groge: Likani, Mathelo, Hakra, Kadasur, Kot Dijji (a small settlement).
- Towns on the main branch of the Indus: Sakara (Sukkur), Darbelo, Thul Mir Rukan, Kot Lalu, Depar Ghanghro, Brahmanabad.
- Town on the deltaic eastern branch of the Indus or Eastern Puran: Dhaliya (Mirpurkhas).
- Towns on Hakra (on spill water from the Indus and the Sutlej): Vinjrot, Ther, Amarkot and Naukot.
- Towns on the deltaic western branch of the Indus: Sudheran-jo-Daro, Rawar, Budh-jo-Takar, Kirr Kot, Shah Hussain, Tharri, Gujjo, Pir Patho, Jeherruk and Nerun. (Location of Nerun cannot be Hyderabad but some place 10 or 15 miles south, and above Tando Muhammad Khan, at the foot of Ganjo Takar hills on their southern edge).
- On the Baran drainage system, were following towns: Taung, Pokran and Dosi.

499 – 700 AD.

The western branch of Indus leading to Manchar had an important town of Dhamraho on it. Vinjrot, was on Hakra which was dry but the latter was getting spill waters of the Indus and Sutlej. Baghrur was small settlement near Alore, Bagharur and Mathelo depended on water supply from the eastern branch of the Indus, passing through Alore Gorge. Bagharur may even have been on Sukkur Gorge, which yet may not have gained importance. Change of courses of the river Indus in lower Sindh, around 700 AD, laid waste many important towns in the lower Sindh, around 700 AD, which then survived as

insignificant settlements. Such was fate of Naokot, Dhaliya, Nerunkot, Jheruck and Sudheran-jo-Daro.

700-1000 AD.

By 850 AD, the Indus River had re-established it-self and became most kind to Sindh's agricultural economy. The course of Indus which passed through Alore Gorge until about 1000 AD dried up and river passed through Bakhar Gorge bringing importance to Baghrur (Rohri?) and Bakhar/Sukkur. The Western Branch of river Indus, which took off along the alignment of Begari canal passed into Sindh-Hollow, but it also shot up a branch near Rustam in Shikarpur district almost along the alignment of the Western Nara, met the other branch near Kakar and thence flowed to Manchar lake. The main branch after leaving Bakhur Sukkur gorge had Thul Mir Rukan and Kalri on it and was passing west of present Nawabshah near the Nawabshah Engineering College. It also had shot-up loop west-wards along alignment of present Rohri canal from Kandiaro to Saeedabad. The deltaic eastern branch of southern Sindh started north of Thul Mir Rukan and Brahmanabad stood to the west of it. It ended in the Eastern Puran. The main branch bifurcated some 30 miles east of Jherruck and its western deltaic branch passed near Gujjo and Daybul (Bhanbhore/Barbarican). The main branch ran almost parallel to present course but 30 miles east. So many branches of the Indus brought agricultural boom, and prosperity, leading to an independent dynasty of Habaris in Sindh. It was also age of "Climatic Optimum" and therefore there was agricultural prosperity and peace.

1000-1500 AD.

From the 10th century to the end of thirteenth century, the river changed its course at least thrice, near and below Brahmanabad as Soomras had to shift capital from Brahmanabad (Mansura) to Thari (ruins in Taluka Matili), Muhammad Tur (ruins 5 miles north of Jati), and Thatta. Brahmanabad was burnt by Muhammad Ghazni in 1026 AD, and is in ruins since then.

Daybul was burnt by Khawarism Shah in 1226 AD, and so was Pari Nagar. Spill waters to Hakra also reduced, and settlement of Vinjrot decayed. Rann of Kutch seems to have completely dried up in the 13th century as Pari Nagar no longer existed and no other port developed.

The Hydrological changes over these five hundred years in the lower Sindh, left many minor branches to flow, resulting into many new settlements depending on rice cultivation and fisheries. More than 1000 such settlements have been explored and reported in Pakistan Archaeology No. 8 (pp. 132-135 and map).

One the western branch of the Indus, in the northern Sindh, raised a beautiful Soomra town of Janani, the ruins of which exist in Warah Taluka.

The main and central Branch of the Indus shoots up a branch opposite to Radhan and passing through Maha Lake. It took the course along Kakar, Baghban, Phaka, Bhan,

Samtiani, Rel, Arazi and joined Indus again creating a vast lake between Sehwan and Talti. This branch made Mehar, Khairpur Nathan Shah and Dadu Talukas and eastern part of Johi and Sehwan Talukas, as most important area in Sindh in the 15th and 16th centuries.

Around 1300 AD, the western deltaic branch of the Indus in the lower Sindh abandoned its alignment along Kalri canal and Samui settlement on it decayed. A new port called Lahri replaced Daybul.

Kalan Kot was built probably in 14th century along with Thatta.

Shah Kapur Muhammad Tur (was abandoned by deltaic branch Gungro of the river, some-time around 1300 AD. By about 1351 AD. Janani was already in ruins. It may have been burnt by Sammas, who used violence to over throw Soomras.

Settlements in 1500-1550 AD.

No major change took place excepting that the loop branch which main branch had thrown north of Darbelo, from to Radhan to Sehwan dried up. The remains of old courses are shown by series of lakes namely Maha, Sutiaro, Jokhpari, Pir Gunio and Talti.

1550-1700 the Little Ice Age.

This was a period of the Little Ice Age in which snow melting in Himalayas was not only delayed for 15-30 days, but quantum of water was reduced. Inundation season was also delayed and as a consequence, peak flow of water in the river was reduced. It was therefore, that the river did not change its course. No new towns came up. Cultivation was reduced, small settlements were abandoned and large settlements reduced in population and size. Famines were frequent and population too reduced.

Settlements in 1701-1758.

It was the period of short warming during the Little Ice Age and Kalhoras increased irrigation from about 1.0 million acres to 2.1 million acres and population from 1.5 millions to 3.0 millions. New towns like, Shahdadkot, Kambar, Warah, Mehhar, Kairpur Nathan Shah, Mirpurkhas, New Khudabad (Near Hala), Shahdadpur, Naushero Feroz, Thari, Khangarh (Jacobabad), Fateh Garh, Garhi, Johi, Cost Ali, Kumbar, Ratan Dera (Rato Dero), Waggun and etc., came up. Shikarpur in Dadu Taluka was renamed as Khudabad and made Kalhora's capital of Sindh. The other towns established during the period were Khairpur (Mirs), Bhirya, Naoshero Feroz, Moro, Khunhera, Sakrand and Tando Adam.

Settlements, 1758-1843.

In 1758 AD. The main branch of the Indus changed its course near Hala, which course it had occupied for some five centuries, deserting old towns on it, some important of which

were; Oderolal, Nasarpur, Shaikh Bhirkio, Tajpur, Agham, Thari, June, Fateh bagh, Talti, Talhar and Badin. On its western deltaic branches abandoned towns were; Jhok, Bathoro, Pir Patho, Shah Bundar, Thatta, Kalan Kot and Sakro. These have survived as less important towns except Kalan Kot. New course was established along the present alignment through Hyderabad-Kotri Gorge. New towns emerged on it and some old towns on new course also gained importance. Hyderabad, Keti Bundar, Sujawal and Tando Mohd Khan were new townships. Old settlements like Budhapur and Sonda of medieval times gained new importance. Hyderabad new capital of Sindh rose to great importance. Naudero, Lakhi, Junidero and Ghari Khairo also gained importance.

Since once million acres of land were abandoned south of Hala, a large number of small settlements dating back from 12^{th} to 15^{th} century (i.e., Samma-Soomra Settlements in the lower Sindh) perished in the lower Sindh).

Settlements in Sindh 1850-1960.

The pattern of settlements started changing after 1860 when the British started extending and improving new canals. Within next 40 years the area under irrigation was three folds of 1843. This increased settlements in the irrigated area causing decline in pastoralism in Thar and Kohistan by migration of population to irrigated plains of Sindh.

Present problems and the future of the River Indus.

Post World War-II irrigation developments in India and Pakistan lead to construction of a large number of barrages and water storage dams on the Indus and its tributaries. This resulted in reduction in water in the lower Indus entering Sindh, during summer and drying up in winter below Sukkur. No water flows below Kotri for 10^{th} months of the year and there is only regenerated (seepage) water from embankments between Sukkur and Kotri for 8 months of the year and its volume reduces to less than 1,000 cusecs the months March to May each year. This has lead to environmental changes in the whole riverain areas in Sindh. Of the total 1.8 million acres between the levees one third was agriculture land one third forests and balance one third abandoned and active river channels. Since 1973 the post Tarbela era the riverain forests in Sindh have dwindled. The agriculture land which was flooded once a year for preserved moisture cultivation is no longer getting moisture and cannot be cultivated, except by tube-wells, which are very costly and are always prone to be flooded by periodic high flood coming once in a decade. The natural vegetation on which animal husbandry had survived is no longer available in quantities as before, hitting this industry very badly. The riverain area had no wind erosion problems, which now have multiplied. Riverian fisheries have been totally lost. The natural fauna of the Indus River have been reduced in population. The Indus Dolphin is threatened to destruction. In the coastal areas, where sea and river waters met and these brackish water were taken by sea waves and estuaries some 25 to 40 km inland and were responsible for supporting 1.0 million acres of mangroves, as well as making these vast forests as breeding ground for shrimp, lobster and hilsa or Indus palla are effected badly and the catch has reduced considerably. The mangroves which provided

fruit as food for populance, feed for cattle, crustaceans hilsa and other fishes, timber and fuel wood for urban use, are dying.

Because of very low slopes of the ground, the tides travel some 80 km up-streams the levees, causing decay of a large number of settlements like; Ghorabari, Keti Bundar, Shah Bundar, and many others, because water not only within the river levees, but also out-side has turned brackish and human and cattle can not survive on such water. This desertification occurred in last 20 years.

The agricultural and forests land in the riverain areas employed about one person per acre in terms of fuel, timber, fruits, vegetable, cattle, feed and fisheries. An estimated 1.6 million people have become unemployed due to environmental degradation.

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