History of Irrigation

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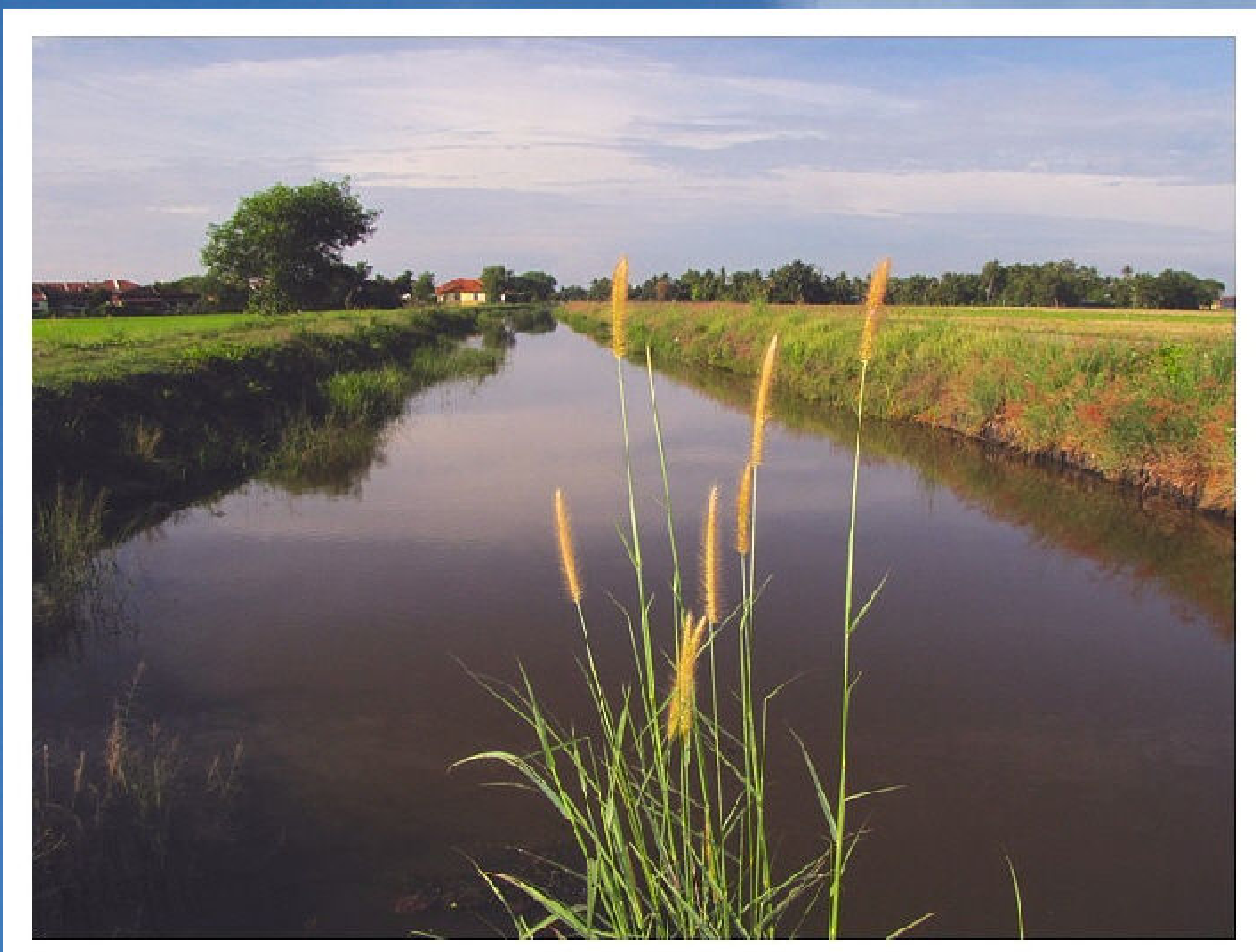

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CHAPTER 1

INTRODUCTION

General
Definition of the history is: It is the history of production, history of the means of production, history of control over the means of production and history of distribution of production. Since soil, water and climate control the production and environments directly control it too thus the history essentially is the history of environments of the past. The province like Sindh, which to its western hill tracts (Kohistan), is an extension of Irano-Baloch desert and the east sandy Thar, is an extension of the Great Indian Desert. It is essentially a desert, but its central alluvial plains, which are irrigated by the River Indus, making that area a vast oasis in the midst of the two harsh deserts of the world. The history of Sindh therefore is the history of production by the River Indus and the history of its changing courses, which invariably have led to famines, starvation, deaths and change of dynasties, each with such catastrophe. The Indus plains have supported as much as eighty percent population of Sindh. The fluctuations in the level of River Indus are governed by snow melts in the Himalayas. When summers are mild and snow melt is reduced, the level of water in the Indus goes down. In such cases canals do not flow to their full capacity, the area under cultivation is reduced and so the productivity. When it is warm in the Himalayas canals flow full and area under cultivation is increased. The level of water in the Indus is also governed by the rains in the catchment of its five tributary rivers in Punjab and Kashmir. When rains are sporadic, flood conditions prevail in the Indus in Sindh. Thus history of production in Sindh also depends upon climatic conditions in the East and the West Punjab, Kashmir and the Himalayas ranges to their north.

The Thar and the Kohistan support about twenty percent of the total population of Sindh on pasturelands and their prosperity depends upon the rainfall in Sindh. When there are long periods of cold, rainfall is also reduce and this reduces the area under cultivation. The people then resort to pastoralism. Since pasture can not support the whole population of Sindh, famine conditions prevail and population is reduced due to over all low production. When the production is low, not only population is reduced but also quality of socio-economic life is affected in all spheres of life.

To control the production and its distribution, the ancients developed caste system; kings (Khatris) to subdue the people by the force of armies, Brahmans (educated and religious people) to collect taxes, administer on behalf of kings and to regulate and distribute production among the whole population not according to their contribution to production but according to their ability to buy Vaish to own the land and get it cultivated and trade in various items of production and finally the artisans and farmers (Sudras), to produce goods and services for the use of the above three communities as well as for themselves. The caste system probably originated during the Early Indus Civilisation and was adopted by the people who professed the Aryan religion, many a millennia later. The caste system existed in Mesopotamia, ancient Egypt, Meso-America and Hwang Ho (the Yellow river) valleys. Thus there is nothing wrong with caste system, as it was developed to encourage production and regulate its distribution. The caste system became oppressive and rigid in a decadent society in India later on and its influence on production became negative.

To understand production in a country like Sindh, we have to know irrigation, which was primitive until 1850 AD and in addition behaviour of the Indus was not known. It is mainly due to extended efforts of the British engineers and some administrators, for almost a century that the behaviour of the River Indus in Sindh became clear. The river comes laden with silt, which in the inundation season easily reaches six parts per thousand parts of water. In Sindh the slopes do not permit adequate velocities for water to hold all this silt in suspension. This specially happens in areas where water overflows bed of the river. The silt thus gets deposited more on the banks and less in bed of the river. The process continues for many decades, until the river flows on a ridge above the surrounding country, protected in its bed by embankments thus created by it. One of the days it leaves the ridge and starts flowing in a low lying area, gradually raising it again. This process has been in action throughout Sindh's recent geological history. Sir Claude Inglis, a well known engineer of Sindh, discussed the question and produced a contour map and possible ancient courses of the river.

Lambrick in his "History of Sindh" (1964), elaborated Inglis's hypothesis, and suggested various courses of the River Indus since Alexander's time. This highly polished work was based on the writings of Haig, Cousens, Whitehead, Stein and many others. Pithawalla, who also used all the above sources except the last one, had arrived at the same conclusion in 1936. In continuation of Lambrick's work the present writer drew a map of courses of the River Indus based on aerial photographs in 1966. D. A. Holmes and Wilhelmy are the two latest workers on the courses of the River Indus.

These studies show that the ancient courses of the River Indus were almost parallel to its present course and they have left ridges, on which the major canals of today are aligned. The branch canals are also aligned on some other ridges and so are minors. The courses drawn from aerial photographs show that there is no place in the central alluvial plains of Sindh, more than four miles long and four miles wide, which has not been intercepted by the River Indus at one time or another during the past 10,000 years after Sindh emerged out of receding sea, which 12,000 years back had flooded the whole of Sindh up to Multan. A map of these courses from aerial photographs on 1:250,000 scale and size 40 x 90 inches has been drawn, covering the past five to six thousand years or since the time of the Early Indus Civilisation. Some old beds of the river were actually utilized as canals as much by ancients, as by latest ruling dynasties - Kalhoras and Talpurs. The British used them for alignment of the Sukkur Barrage canals in 1932. They were also used for Guddu and Kotri barrages canals as late as 1960 and 1963 respectively.

When the river changed its courses, the irrigation system in the affected area was totally destroyed bringing about migration of people, chaos, disease, famine, starvation, death and consequently decrease in population. This has been the history of Sindh for the past five thousand years-that of prosperity, high population, depression, reduction in population, change of dynasties, rise and decline of civilisations, and abandonment of cities and settlements, each leaving behind heap of ruins popularly known in Sindh as “Daro” or mound of earth with scattered shreds of pottery, burnt bricks and some artifacts. Thick forests only guaranteed limited stability of the river in its active flood plains. The forests kept velocities of water low in the flood plains and high along active course. This caused heavy silt deposition along the embankments covered with trees and as the level rose high, there stood more chances of the river’s abandoning old bed and also abandoning the irrigation canals, which had their heads not in the active bed of the river but away from it in the active flood plains, usually having forests around it.

This pattern of tapping the river for irrigation continued until 1932, when the Sukkur Barrage was constructed to irrigate sixty percent of total area of Indus plains in Sindh. In another thirty years rest of the two barrages were built. The heads of many canals, as they stood before the barrages, still exist within the flood protective embankments and can form a subject of special interest to archaeologists. The old canals, which were partially merged into new canals, have their un-merged portions partially intact at least at the present, though many settlements along their embankments have disappeared and have gradually been reclaimed for cultivation.

In the pre-British period there were no levees or embankments to contain the river within its flood plains, which were twenty to thirty miles wide. In order that in the inundation season the permanent villages and towns are not wiped away, embankments were constructed around them and were strengthened from year to year, but in real sense they were not a guarantee against breaches. Rodent and reptile holes occurred and went un-noticed until flood waters entered and widened them. Since anything could happen during floods, in cases of major threats, women and children were evacuated along with grains and cattle, able-bodied men patrolled the banks and old men watched the houses. Once water entered the settlement, usually the higher spots were not flooded and old men stayed behind to witness falling of mud-house walls and thatched roofs.

Before the British conquest of Sindh in 1843 AD, with exception of very large towns like Sukkur, Rohri, Shikarpur, Hyderabad and Thatta, there possibly were no burnt brick houses. Burnt brick was limited in its use to religious structures i.e., mosques and tombs. Sindh had developed another peculiar architecture for mud wall construction in two or three storied houses. This type of structure is now disappearing and needs protection like old monuments. The anti-flood protection method of house construction was unique and probably limited to Sindh. Foundations were excavated more than a metre deep to form the mud wall foundation but before pouring and pressing wet mud lumps in these foundations a reinforcing structure of wooden branches or poles about 3.5 to 5 centimetres diameter was erected just like reinforcing of walls in earthquake areas. Wooden poles were laid at every 8 to 12 centimetres vertically and horizontally. Wood was well cured, dried and coated with some material. The reinforced structure was 4.5 metres high for a single story, 7.0 metres for double story and 9.5 metres for three stories. At ceiling level, reinforcement for support of roof was increased by providing a number of poles laid edge to edge horizontally on the top of mud wall to from a wall beam, to take load of wooden beams and rafters for the roof. The foundations and walls were packed with clay mud, which was laid in layers about 40 cms high and allowed to dry for a week or two before adding another layer. Since clay absorbs water, it shrinks on drying and develops cracks, these cracks were filled with wet mud and finally plastered with 1 to 1.5 cm thick mud and wheat or rice straw mixed together. Straw acts as reinforcement and if mud, diluted in water is applied above it in a thin layer of one to two millimetres, it becomes air tight. The floods, if they came in the town, could at the most damage outside mud to a depth of half to three quarters of a metre, but water could not enter the house as its ground floor was filled with earth to a depth of about metre or more, before laying bricks floors. Such houses have disappeared in Mathelo, Larkana, Halani, Kandiaro and Nasarpur, giving place to brick wall houses, but a few still exist in Sehwan, Rohri and Thatta. Flood water actually entered Thatta in 1955. The town was submerged and some houses collapsed but all wood reinforced mud houses, even of three stories, defied the Indus flood. Forty years ago the present author stayed on the third floor of a house, which probably was constructed for a Mughal noble man, some three hundred or more years ago. Each floor had a bathroom lined with lime plaster and had recently been partly repaired with cement and concrete. Drainage pipes, as they existed, were made of burnt clay tiles, telescoped and lime plastered. Today these are archaeological monuments and need protection as such, but none has thought of them and may be replaced by the owners with brick houses, in a decade, if action is delayed.

A modification of this design was; houses made from babul (acacia nilotica) wood. Wooden planks about 25 to 35 mm thick were laid edge to edge and nailed together with 25 – 35 mm diameter wooden pieces of tamarisk, each about 75 to 100 millimetres long and nailed at 75 to 100 millimetres intervals along the whole length of planks. This was the type of construction of late eighteenth or early nineteenth century, as they invariably have used machine made iron nails and doors and windows hinges and bolts are typical of that age. The enclosed photograph shows a three story house of that period, still under occupation and although outside mud plaster is wearing out, the inside is kept in a good shape. The house is leaning on one side but it does not disturb the occupants. At least one dozen such houses are still occupied and all of them were submerged more than a metre deep, in 1955 floods, for two to three weeks and yet they did not collapse.

The poor men's houses had walls of thin tamarisk branches (1.5 – 3 cms diameter), fixed edge to edge in 3-4 rows vertically and woven together by similar branches running horizontally about 30 cms apart. They were further strengthened by reed ropes. They too defied the flood and were a common feature in the active riverine flood plains. History of irrigation in this book is history of agriculture and agro-industrial products, which lead to rise and fall of civilisations, dynasties and kingdoms, prosperity, poverty, famines, starvation and deaths of people who depended on the vagaries of River Indus and its waters.

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CHAPTER 2

CHRONOLOGY OF IMPORTANT CULTURAL EVENTS AND DYNASTIES OF SINDH

S. No.	Event	Years
1	Stone Age in Sindh	500,000 – 4,000 BC
2	Very dry climate	Before 9,000 BC
3	Very dry to beginning of low wet period	9,000 – 7,500 BC
4	Climate changes to medium wet	8,500 – 7,500 BC
5	High wet climate	7,500 – 4,000 BC
6	Medium wet climate	4,000 – 1,750 BC
7	Hyper arid climate	1,750 - 900 BC
8	Medium dry climate	900 BC – 500 AD
9	Mesolithic period in Sindh	10,000 - 6,000 BC
10	Beginning of Neolithic Revolution in Sindh	7,000 BC
11	Beginning of Chacolithic period in Sindh	4,000 BC
12	Early Indus culture (Amri, Kot Dijji)	3,700 - 2,300 BC
13	Mature Indus culture (Mohenjo Daro)	2,300 - 1,650 BC
14	Declining Indus culture · Jhukar · Jhangar	 1,750 - 1,350 BC 1,200 - 900 BC
15	Rise of Rig Vedic tribes	1,050 BC Swat 850 BC Balochistan 800 BC Sindh
16	Mahapadhayas (Kingdoms) of the South Asia	600 - 500 BC
17	Achaemenians	519 - 450/400 BC
18	Sindh Principalities	450 - 400/325 BC
19	Alexander and his successors	326 - 323 BC
20	Mauryans	321 - 184 BC
21	Bactrian Greeks	184 - 70 BC
22	Scythians	70 BC - 46 AD
23	Parthians	46 - 78 AD
24	Kushans (Upper Sindh)	78 - 175 AD
25	Parthians (Lower Sindh) and the whole Sindh after 175 AD	78 - 175 AD 175 - 283 AD
26	Sassanians	283 - 356 AD
27	Vahlikas	356 - 415 AD
28	Unknown Sindh principalities	415 - 499 AD
29	Rais	499 - 641 AD
30	Brahmans	641 - 712 AD Whole Sindh 715 - 725 AD Eastern Sindh
31	Umayyad Governors	712 - 746 AD
32	Abbasid Governors	751 - 854 AD
33	Habaris	854 - 1,011 AD
34	Soomras	1,011 - 1,351 AD
35	Sammas	1,351 - 1,525 AD
36	Arghoons	1,522 - 1,554 AD Whole Sindh 1,554 - 1,587 AD Upper Sindh
37	Tarkhans	1,554 - 1,591 AD
38	Mughal Governors	1,587 - 1,591 AD Upper Sindh 1,591 - 1,700 AD Whole Sindh 1,701 - 1,736 AD Lower Sindh
39	Kalhoras	1,701 - 1,783 AD
40	Talpurs	1,783 - 1,843 AD
41	British	1,843 - 1,947 AD
42	Government of Pakistan	1,947 to – date

CHAPTER 3

BEGINNING OF IRRIGAITON

Ancient irrigation canals and their peculiarities

In order to understand the irrigation system, as was being practised before the advent of modern engineering methods of topographical survey and design, study of pre-British period canal system is necessary. Fortunately, for us there is complete record of pre-British canals, their lengths, areas under their command, the slopes and directions of canals, silting and de-silting problems and special levelling problems created by use of bare eye and human judgement against use of dumpy levels, rods and chains. Hughes Gazetteer of 1,876 gives list of 729 pre-British canals and their source of supply has also been listed. Following are a few conclusions, which apply to all canals operating form the days of early irrigation in Sindh.

- Canals lay obliquely to the direction of flow of the Indus in most of Sindh, exception being the area north-west of Sukkur and west of Kashmore. This was done to get better slope for the channels, so as to reduce silting problems.
- No canal had its mouth where the river had relatively a permanent bank (Sukkur and Hyderabad).
- The canals were not deep enough to draw water form the main channel of the river in early or late summer and whole winter.
- The canals some times had sharp bends causing serious erosion or silt deposits.
- Old beds or abandoned branches of the river or a part of them often were converted into canals. Such branches often had poor slopes, awkward bends and needed annual cleaning year-after-year.
- Most of the canals supplied water by gravity during most of the inundation season, but acres of land must have gone out of cultivation. Occasionally water had to be lifted from them, by means of Persian wheels to irrigate adjoining lands. There were canals or major portions of them, which were flowing in the cutting and water had to be lifted from them to the adjoining lands all the time.
- Some important canals like Sindh Wah and Begari, instead of having mouth from the Indus, took off from Sindh Dhoro, an old bed of Indus parallel to its present bed and filled with water year-after-year. Some of them were given more than one mouth.
- Choking up of mouth of canal by silting or fall into the level of river created precarious conditions for the farmers. Late rise of the river led to late planting or its early fall resulted into lack of final dozes of irrigation. In both cases the crops were poor. Lifting or pumping of water in itself was time-consuming. Low lift Persian wheels for three to four feet head, supplying a quarter cusec of water at best and operating a maximum of eight hours a day, could not command more than eight acres during the inundation season. The farmer was not able to recover the labour charges, assuming that animals were fed on pastureland without use of

special feed grown for them and paid only for labour to operate Persian wheel and to graze animals.

- When river had no flood protective embankments, floods were more frequent and the chances of destruction of crops high.
- No regulators were provided at the heads of canals.
- No consideration was given to the slope and cross-section of the canals to maintain a velocity of water, so that neither silting nor erosion may take place.
- Had the canals enough length, and had they been planned that they will be sufficiently wide and deep and have free run for some miles, before they supply water by gravity, water could have been made available to the farmers early as well as late in the season, to ensure availability of irrigation water during the whole inundation season.
- Due to these uncertainties beyond their control, pessimism and fatalism has prevailed in Sindh's farming community over the centuries and every thing is attributed to the will of the Almighty. It has done irreparable loss to their thinking, leading to belief in superstitions.
- Since crop could fail any year, the farmers adopted animal husbandry as a source of additional income. As the river water flooded vast areas of land outside cultivated area and luxuriant grasses grew on them, farmers raised cattle on these pastures, providing them with an assured source of income in the lean years.
- Since flooding of land and destruction in normal years must have taken almost same proportion for Sindh as a whole, loss of crops in terms of percentage under irrigation must have remained almost the same, and production most probably changed very little, except when major hydrological changes in the course of the River Indus took place. Before opening of Sukkur Barrage in 1932 AD every farmer was a pastoral too. Failure of one therefore did not totally ruin the farmer. He sold his extra livestock to meet urgency.
- Some lands lying above the level of water in the canals, though within the command area and fertile, were left un-cultivated.
- Only Kharif crop could be grown on these canals. (Kharif crops are sown in June-July and harvested in September-October).
- Many times canals did not have their mouths in the river itself, but rather in lakes and depressions like Sindh Dhoro, which were filled up naturally or artificially in the inundation season. This helped in silt depositing in the depressions and canals did not have serious silting problems. On the other hand, level of water in the lakes was always lower than the river, therefore canals did not attain the levels they otherwise could have, reducing the area under command, and also the number of days water could be supplied. However fluctuation in level of water in these lake depressions was less than the main river during short intervals.

Due to these peculiar circumstances there were hardly any famines in Sindh. The only famines reported by Bhatia in Sindh since 1,799 AD, were in the Upper Sindh in 1,820 and 1,822 AD and most probably were due to famous Kashmore floods destroying present Jacobabad, Shikarpur, Larkana and northern Dadu districts. Even recurrence of Little Ice Age may have caused it. Similar floods took place in 1942, 1948 and 1973 AD.

Sindh must, however, have faced famines for some years continuously since 1758 AD; when the River Indus changed its course near Hala, abandoning its old bed passing near Nasarpur, Shaikh Bhirkio, Tando Ghulam Ali, Old Badin, Kadhan and Rahimki Bazar to the present course; west of Hyderabad. As a result at least one million acres, which two centuries later were reclaimed, were re-irrigated after opening of Kotri Barrage canals in that area in 1961 AD.

The history and need of water lifting devices in the ancient Sindh - Boka or Shaduf.
Boka (leather water bucket) was known in the Indus Culture times. Pulley was not known then. Boka therefore was pulled up the well, by a long lever hinged over an inverted U-frame fixed in the ground (found at Lothal) or over a tripod similarly fixed. Similar device was in use in Egypt around 4,500 years ago.

The limitation to lift was the height of U-frame or tripod. Ordinarily it could not be over ten feet. Multiple pulley was known in Mesopotamia around 900 BC. Simple pulley was much earlier innovation. Its existence in the Indus Culture is not proved technologically. Its knowledge may have reached from elsewhere or may have been developed for irrigation during the Declining Indus culture (1,650 to 900 BC). It was in use in Egypt around 1,500 BC and probably also in Sindh by this date.

The Boka seems to be originally a device adopted in Sindh from central India. It is similar to the one used in Daccan and Madhya Pradesh. Boka has an advantage over the Persian wheel in as much as it does not spill water back into the well. It has the form of a tea kettle with a spout. It is raised or lowered from its top, with rope over a pulley. Other but smaller pulley kept at a lower level to pull spout. When the bag passes over the level of the smaller pulley, the spout is pulled horizontally and the water rushes out from it into the outlet already built. Boka or shaduf of the Mature Indus culture is discussed in chapter 10.

The disadvantages of Boka are:

- The animals for each turn have to walk forward and get back in the reverse. This walking back in the reverse is a very hard and slow job for the animals unless wells are very deep and animals can be made to walk normally in forward and backward direction, while returning back.
- At least one person is needed all the time to guide the animals and another to watch the lower pulley and guide the rope over it.

The capital outplay on the Boka devise is much less than that on the Persian wheel, but its hourly discharge does not match with that of the latter and instead of two adults even a child was able to guide the animal in the case of Persian wheel.

Animal Power
Animal power used in Sindh may have been oxen to start with. Camel may have been used around 1,000 BC. Camel is reported to have been domesticated in Saudi Arabia around 1,200 BC. Camel bones found at Mohenjo Daro show its presence in Sindh around 2300 BC. Camel may well have been domesticated here in Sindh earlier than in

Arabia and used as pack and riding animal. It may have pulled Boka and Persian wheel when their knowledge reached here. Once there were trade contacts between the Indus and Mesopotamia and use of pulley for loading of wooden logs may have been common on boats. The pulley therefore may have been present in the Jhukar times or soon after 1,500 BC.

Persian Wheel

Persian wheel is a much later development. The gearing system used in it transmits power from a vertical axle to a horizontal axle by cogwheels, working on the principle of bevel gears. Cogwheel was probably first designed by Achaemenians and Greeks for their war machines like wall scalers, stone throwers etc., around 250 to 200 BC. The Greeks seem to have used cogwheel, to develop water lift wheel, now called Persian wheel. Low lift wheels may have been developed before high lift wheels. Persian wheel has limitation to lift water from long depths. It cannot work satisfactorily beyond 30 feet depth, as the endless bucket carrying ropes will slip due to heavy weight of buckets filled with water, without reducing the number of buckets. Boka is much more efficient than Persian wheel for depths of more than thirty feet.

Persian wheel may have reached Sindh during the Bactrian Greeks or Scythians rule from 184 to 80 BC and most probably in the second century BC.

Low lift Persian wheel is very efficient among the ancient water lifting devices and is only next to Archimedes screw, which again has limitation to very low heads of one to one-and-half metres, above which it cannot perform satisfactorily.

Use of Persian wheel was common before the British and it was a must, in more than fifty percent area in Sindh, for raising and harvesting the crops successfully on the inundation canals. The number of canals taking off from the Indus has varied between five hundred to one thousand at various times. The level of water in them had varied with the level in the river. When the level was low as in late May or early part of June, farmers used Persian wheels to sow the crops (specially cotton, rice nurseries, vegetables and fruits) and when water level receded in late September or early October, water wheels were used to irrigate crops to maturity. The Persian wheels were operated by one camel or one or two bullocks, depending on the lift and number of bucket on the endless string, acting like a belt.

Camel was preferred, as oxen needed better fodder and feed while camel browsed on wild shrubs and tree leaves. Camel also walks faster and does not tire soon.

Simultaneously with wind turbine, whose 4- blades were copied from sails of boats, most probably, the wind mills operated Persian wheels. Persian wheels were not as popular in Iran as they were in Sindh. Medieaval Arabs describe the Persian wheel as Sindhi wheel.

Diesel operated pumps for irrigation were introduced in Sindh during the World War-I. Such centrifugal pump was operated by 32 H.P. Ruston diesel engine imported in 1917

AD was still in use at Sakrand in 1957 AD. Such diesel engines replaced Persian wheels during World War-I, on the irrigation wells in Malir near Karachi, as the water table had dropped from thirteen feet in 1860s to thirty feet in next 50 years. Today it is 100 feet or more deep.

Persian wheel irrigation in Sindh in the pre-barrage (1932) days and its typical patterns: In pre-barrage era where lands were at a higher level than water in the canals, pumping had to be done by Persian wheels during the whole season. Considering labour and animal time, it was highly un-economical, but animals grazed on waste government lands and men had no alternative occupation, so this was the best one could do to have some income rather than none.

Where the canal water level was higher than surrounding lands, during the peak inundation season but not at the times of sowing the crops or its final stages maturing, Persian wheels were used during the low canal level. Where canal level was higher than surrounding land during growing season of four to five months a year, summer crop could easily be raised during inundation season, but there also were areas sufficiently above the water level and in this case too water had to be lifted.

The above three methods of irrigation applied only to Kharif or summer crops raised between June and October/November, but in some areas winter irrigation too was resorted to by following methods:

The Indus had a western branch, called the Western Nara. At various times of history it started from north of Kashmore and then south of it. In the beginning of nineteenth century it started near Sukkur and finally ended in the Manchar Lake, from where it went, by Aral canal, to the Indus again. Nara was a perennial canal and depending on the levels of adjoining lands, it supplied water by gravity or by lift with Persian wheels. It carried substantial discharges to be navigable year around and therefore played an important role in shipping and the prosperity of Larkana and Dadu districts. This branch of the Indus was responsible for Rabi (winter) cultivation as well as perennial irrigated crops, some of which were fruit crops like mango, lemon, orange, zizyphus Mauritania or ber and etc., winter vegetables of all categories, tobacco, Bhang (Hibiscus), wheat, barley, oats and winter oil seeds.

Besides the Manchar Lake, Sindh had number of lakes formed mostly by the old beds of the River Indus or Hakra. These were filled in summer and water was lifted from them in winter for Rabi as well as perennial crops. Lakes also provided a number of exotic root crops and vegetables.

There was another type of irrigation from the River Indus called Sailabi. In this type of cropping system, land was flooded in summer and winter crops were raised on preserved moisture. Such areas were natural depressions or lake beds (including Manchar), which were used for winter crops when water from them was drained out for other purposes or evaporated. The riverine areas flooded in summer were and still are also utilised for

Sailabi cultivation. When done deliberately by the man, it could be categorised a separate kind of irrigation.

Winter crops, called Dubaris (second crop) is another innovation in the rice areas where ground is fully saturated with water by early August. After the harvest of rice crop in October-November, water table still is about one or two feet deep and surface is wet. A Dubari crop of oil seeds, peas, beans, wheat and barley is raised on it. The selection of crops is governed by rate of fall of water table to eight. feet. If it occurs at end February, peas and oil seeds are raised and if it is sustained until end March, wheat, barley and horse beans are grown.

The first of the two methods goes back to Amrian times and can be considered as rudimentary irrigation. The second method (Dubari) is post Mohenjo Daro development and probably started in Jhukar times after 1650 BC, with introduction of rice in Sindh.

CHAPTER 4

DESPOTISM IN SINDH; A NATURAL CONSEQUENCE OF IRRIGATION - A COMMON FEATURE IN ALL IRRIGATED ARID LANDS OF THE NILE, THE TIGRIS-EUPHRATES, THE HWANG HO, THE MESO-AMERICA AND THE INDUS VALLEY

Despotism cannot occur within the strong centres of rain-fed agriculture, as in such areas it does not require organisation for building and maintaining irrigational canals required for water deficient landscape. Irrigation in arid zones ultimately would lead to despotic control by government or government approved functionaries. Despotic control immediately ceases when property based management gets into such areas, with advanced technology and capital.

Irrigation in water deficient landscape has shown advantages, even when a few generations of benevolent rulers have organised, the irrigation works well. This increased population and also produced enough surplus food, which resulted in the urban growth. This in turn supported governmental aspirations of making conquests and created empires. Planted agriculture started in the Crescent (southern Turkey and Lebanon, Syria and Jordon), around 7,000 BC, as it did at Mehrgarh in the Indus valley almost simultaneously. This invention spread from its origins, across Asia and Europe. It started in Egypt and Mesopotamia later than in Sindh, if Mehrgarh is considered part of Sindh up to 1739 AD. In the Indus flood plains men needed a new and further technology to evolve and replace forests with cultivated crops.

They had been growing wheat in areas of Mediterranean climatic (winter rains) zones of the present Balochistan; at Mehrgarh since 6,500 BC, or even 500 years earlier. They had per chance found out that after the inundation, when river receded in autumn, on the preserved moisture of silted land wheat crop could be grown successfully. By this time (4,000 BC), dog, pig, goat, sheep, cattle and onager had already been domesticated. Fishing had already been practiced by means of hooks, harpoons, nets and traps. Hand made pottery was being baked in the kilns. The wheel made pottery was on its way to be introduced.

These people, the early Neolithics, settled in the Indus plains at Amri and possibly at a number of similar villages. Initially they depended only on Rabi crops grown in the above manner. The exact date cannot be ascertained but in all probability in a millennium or so they hit up canal irrigation. Initially it was use of spring water, which by itself flowed out in form of a stream and later on by use of Wahur, Dhoro and Dhori, as discussed in chapter 9. The method must have been to lead water from some lake or river channel into a low lying land. Settlements invariably were built on the elevated areas to save them from flooding during the inundation seasons.

Hunting-food-gathering tribes (13,000 to 5,000 BC) had to work for food, day-after-day, with no planning for future. Development of agriculture was based on planning for future; not only stocking food until incoming crop but for full twenty-four months, if the next year's crop failed due to flood or drought. To produce surplus food more population was required and to feed this increased population more land had to be reclaimed. In article "Sindh - its food resources since antiquity" it is shown that Sindh had capacity to support hunting population of 100,000 around 7,000 BC. Primitive agriculture must give rise to more population and additional population would need more land. With well planned agriculture of early rulers such as Kalhoras, the Sindh province could easily have 2.1 million acres under agriculture and thereby support three million people in rural Sindh. It must be emphasised that Kalhoras' irrigation and agriculture were as primitive as Mohenjo Daro agriculture. Irrigated agriculture would need lot of co-operation and more of it is needed if canals become longer in length, greater in their capacity and larger areas they command. The annual clearance of water courses alone would take away most of the free days of farmers. Even volunteered operations would need a leader or an authority to work under. Such authority was easily developed by co-operating farmers on a canal. The leader first assumed the role of water course or canal management to get water and thereby cultivate his and other farmers' lands, without accepting fully the sub-ordination of the regulation laid by this leader. Larger the canal the leader enforced his regulations of distributing water on basis of probably share cropping and became despot. In times he extended his jurisdiction over a number of canals and even to the new land to be cultivated. Even the most civilised governments in Sindh, in past four thousand years, had to accept him as a co-ordinator at canal or water course level. Many injunctions were formulated to uphold his authority. The central authority in irrigational society then, had to be despotic in nature. This is true of all irrigational societies; not only in the irrigated Sindh and the Punjab but also in Egypt, Mesopotamia, Hwang Ho valley and Meso-America.

Information on Sindh's history, so far collected, reveals that the Mature Indus culture (2,300 BC – 1,700 AD), Vahlikas, Rais, Brahmans, Habaris, Soomra and Samma, Kalhora and Talpur dynasties must have been the consequence of such agricultural management and at least for the past 3,600 years of the canal irrigational system. The short lived rule of Kalhoras was again the outcome of well managed irrigation system and could be equated by the British efforts, after fifty years of their long struggle with the Indus and its behavior.

It was in the arid zones that the agricultural returns were the highest before advent of modern technology. It is on account of this that the arid zones were centers of civilisations, until the industrial and technological advancement of past two centuries. The civilisations in arid zones rose and fell with the Irrigational works and their destruction was caused by natural consequences i.e., climatic changes leading to drought, floods and changes in the courses of the rivers. These changes caused destruction of irrigational works, cultivated lands and settlements resulting in shifting of population to other parts of the country, famines and reduction of population almost to half within a decade or two. Once irrigational system was restored population easily doubled in half a century. Protection of urban centers and some villages by embankments was being practiced for centuries in Sindh but the construction of flood protective embankments by the British was meant to protect not only the settlements and irrigational works but also the land under cultivation. Today such works exist in all the valleys of the major rivers of irrigated arid countries. Though exact patterns and dimensions of government regulations were prevalent in Mesopotamia, China, Egypt and Meso-America, they must have been in force in Sindh from the Jhukar times i.e., 1,650 BC but sufficient data about compulsory participation of every adult male in digging and cleaning of canals and threats of punishments to evade these duties are only available from other countries, specially Mesopotamia and Egypt. To tax the farmer according to area actually under cultivation, the beginnings of geometry are traceable in Egypt, as stated by Herodotus, long before Euclid's 'Elements'.

Unlimited control over the labour power of the subjects enabled rulers of the Indus valley, Sumer, Babylon, Egypt and Hwang Ho valleys to build spectacular cities, palaces, gardens, grain stores and tombs. The irrigational state has despotic leadership and despotic government and is invariably stronger than the society it rules. Government's collecting of land revenue over a vast irrigated tract and maintaining canals meant efficient maintenance of records. Need of such records gave rise to invention of writing, arithmetic and weight system, as multiples of two as well as the decimal system. Once these masters of the society were forced to become record keepers, they easily became great organisers and as a consequence builders of urban as well as irrigation works.

In the third century BC, Magasthenes found Asoka's officials charged with the task of measuring fields, counting people and allocating irrigation water to various users by means of orifices and other measuring devices. Arthrashastra of Chanka (Kautliya) also mentions the canal officials. This could not have arisen overnight, without experience gained over many past millenniums. The canal official of Abbasids had 10,000 men at Merv and assumed powers of a district police chief. Abbasids may have tried similar set up in Sindh but with failure as discussed in chapter 23. In order to keep control over the flow of taxes, the authority had to be well informed of irrigational network and taxes arising as consequence of it. An intelligence as well as postal system must therefore have operated from Amrian times. From Achaemenians onwards (519 BC), records of such system and even rudimentary Morse code telegraphy being under operation, are available. In connection with embezzlement by the taxation officials as well as maintenance of irrigation system itself, Arthrashastra states that an official who deals with king's revenues invariably is tempted to embezzle. So government must use skilled spies and king may squeeze them after they have drunk themselves fat. He should transfer them from one job to another, so that they vomit what they have devoured.

The irrigational regimes are frequently theocratic because society, which provides unique opportunity for growth of despotic governmental machinery, leaves no room for an independent position by attaching to themselves, in one form or other, the symbols of Supreme Religious Authority. Inca kings became descendents of the Sun, Pharaoh became son of god or god himself, Mesopotamian kings were quasi-divine, Umayyad and Abbasid emperors titled themselves a Khalifs and appointed interpreters of religious code;

the Muftis. In the South Asia, from Asoka onwards, kings became champions of one or other religion and combined political and religious leadership. The Indus civilisation probably had priest-king, though not proved archaeologically. Under Muslim rule in India, persons directly dependent on the sovereigns, administered mosques and holy shrines. Under Sammas of Sindh religious heads organised opposition to Arghoon aggression. Even after Sammas' overthrow they continued resistance against Arghoons in the hope of restoring them back.

Kalhoras were religious Pirs and called themselves Fakirs. The religious endowments or Waqfs, which provided support to the mosques, were usually administered by the state. In an irrigational society such measures prevented the Islamic clergy becoming independent of state. This is also the reason that in an irrigated society the religion invariably has placed itself within the authority of the state, without preventing itself from domination of the state. The table below shows how successfully the rulers/leaders imposed their religion on the ruled, who adopted their religion. The British were successful in imposing law in the land, which was secular and under strong administration they enforced secularism bye-passing the religious domination. The Table below gives religions of the ruled and the rulers from the Indus civilisation to 1947 AD.

Dynasty or Era.	**Religion of Rulers**	**Religion of majority of population in Sindh**
Mohen-jo-Daro.	Paganism.	Paganism.
Vedic people.	Vedic.	Vedic super imposed on + Mohen-jo-Daro religion which is presented in the form of Upnishads.
Achaemenians.	Zorastersim but did not interfere in local religion.	Jainism (Their rule was short lived).
Alexander.	Paganism.	Jainism.
Mauyrians	Buddhism	Buddhism
Bactrian Greeks Scythians Parthians Early Kushans.	Buddhism.	Buddhism.
Later Kushans.	Hinduism.	Buddhism (Their rule was short lived).
Vahlikas Rais (Sudras).	Buddhism.	Buddhism.
Brahmans.	Hinduism but totally tolerated Buddhism.	Buddhism.
Arabs.	Muslim.	Buddhism.
Soomras.	Ismailism.	Ismailism.
Sammas.	Sunism.	Sunism.
British.	Secula-rism.	Islam/
		Hinduism.

For their dates of rule see chapter 2-11.

The government in an irrigated society puts a number of demands on the cultivators including conscription for war services. The government asks the Jagirdars, Mansubdars and Zamindars to supply soldiers along with arms. Even the British did the same in World War-I and II. For this reason alone, they had tactfully kept the village chief in good humour accompanied by fear. Young men ignorant of war-fare and use of arms, depending on their finding the ease with which they could govern such bravery and chivalry, are collected. Such an army is invariably defeated. This is main reason for frequent occupation of irrigated valleys by outsiders, who permanently settle in such lands and in two to three generations lose their vigour and tactics of war-fare, draw the army from cultivators and are in turn defeated and succeeded by others. This accounts for average life-expectancy of seventy years for various dynasties of Sindh shown in table in chapter 2. This pattern has followed in other irrigated countries too.

CHAPTER 5

SOCIAL AND ECONOMIC STATUS OF FARMER IN AN IRRIGATED SOCIETY

The general pattern shown by status and life pattern of the government or farmers in irrigated society shows that:

- A peasant family of five could grow enough grains by primitive methods, on five acre farm, to feed themselves for a year, if they could keep all the harvest. But this they can not do because they have to pay fifty percent or more as share to the land owner, who is responsible for management and supply of irrigation water and the burden of labour for excavation and maintenance of irrigational system was on the cultivator. The British gradually freed the farmer form this forced labour.
- To supplement their income they worked for others at exploitive wage rates during free time - for slight additional income or food. This is true of Sindh even today.
- Farmer is considered socially inferior in the society and only slightly above the untouchables. The word "Vaish", in the Hindu caste system, applies to owner-cultivator or Zamindar and not to the tenant-cultivator. All along he has inferior status socially, politically and economically and also legally at least in certain societies, which in Sindh exploit him in the name of jirga, elders' decision, spiritual leader, (Pirs) opinion etc. The Sindhi word "Hari" (tenant-cultivator) derived from Sanskrit, means untouchable. Brahmans categorised farmers as untouchables.

Considered legally free, at least since British conquest of Sindh, and not bound to work as statutory labour since 1856 AD. Although in the past two decades there has been social and political awakening among the farmers, yet they are socially inferior, poor, semi-literature or illiterate, backward and almost isolated from social and cultural life, which the other classes of people in Pakistan ordinarily enjoy today.

- After study of life of peasants in different irrigated areas in Indo-Gangetic plains, Hwang-Ho valley, Meso-America, Egypt and Mesopotamia, where different religions and traditions namely Islam, Hinduism, Christianity and Buddhism prevail, which are so different from each other, it is observed that peasants in all these areas surprisingly follow similar practices, namely:
  a) Inheritance of land through the male line.
  b) Joint family, where grandparents and grand-children live under the same roof and work together.
  c) Religious practices, which are similar i.e., visit to shrines of holy men, regard for living holy men and superstitions.

d) Similar social trends, which include suspiciousness, superstition, jealousy and unthriftiness.

e) Part time agriculturists like village traders, pottery makers, weavers, carpenters and black- smiths also fall in the same category as the tenant-farmers and in Sindh they are definitely considered inferior; only slightly better than Sudras or sweepers.

f) Household farms usually do not provide enough income for the labour of the cultivator, in spite of hard work, so he and his whole family engages in other part time jobs including cattle raising and rearing and making of handicrafts etc.

g) They do not use adequate modern agricultural equipment, chemicals and hand tools, and their methods of production invariably are inefficient.

h) They rarely are permitted to participate in the national decision making.

i) Their produce is invariably put under price control by the government and raised only when feared or actually demonstrated that they would give up raising that particular commodity in future. This is true of Pakistan since the beginning.

j) They suffer through insecurity of life and property.

k) Their income from the land as well as from additional labour and occupation can hardly fetch them the required per capita ration of calories. Having suffered, thus genetically, they become small in size because under such circumstances the most likely to survive would be those with low requirement of calories.

l) Their food is most unique, among the basic human adaptations, that it would contain almost no animal protein most of the time. They subsist on plant proteins, which rarely contain all the 21 amino-acid available in animal protein. The human body adapts to protein deficiency by delay in growth of skeleton and slower maturation.

m) In days of despotic over-lordship the farmers are not allowed to sell their produce direct, sell their beasts, or get their daughters and sons married without getting permission of the Sindh's Zamindar, even to this day.

n) Many of the children they produce die prematurely due to lack of health services.

o) There is usually uniformity of dress as well as housing in the farming villages. Up to 1947 AD village women of farming community wore red shirt, Dopatta and Sussi-shalwar, while men wore black or blue 'Gode', coloured shirt and turban of cheapest white cloth. Ajrak was wrapped around the upper part of body in winter. Naked feet for both men and women were not unusual, except when ploughing the field or going elsewhere.

p) They consider large families advantageous. It has been found that large family lives under the same roof, from grandparents to grand- children, because of co-operative nature of work, earn better living and are able to gain better social status in the rural community. Larger number of children is also an insurance against high mortality rate among children.

q) Large number of children does not represent the crushing financial burden to the peasant. They keep birds and animals away from the crops, cut grass, collect fire wood and carry food to the parents in the field. However, the whole family has to work too hard as children's productivity is much lower than cost of their upkeep. In peasant families the birth control campaigns have been ridiculed and doomed to be failure unless their income is raised by government's artificial price control.

s) Because of jealousy among the farming community, if anybody improves economically and by hard work becomes prosperous, the others in the society encourage him to throw elaborate feasts on various occasions and if there is no such occasion in near future, a Khairat feast (feast in name of Allah) is encouraged and whatever little saving was there, with the unfortunate family, is made to drain down into the stomachs of the villagers with superstitious hope that this is a loan, which God will repay by making family prosperous.

t) Handicraft making, usually resorted to in spare time to supplement the family income, is not able to compete with machine made goods, produced at a lower cost, and hardly repay fraction of actual labour.

Since every member of family including girls contribute to the family economy in a peasant society four kinds of marriages of girls are most common:

(i) Exchange of girls i.e., a girl is married to another family in return for a girl from that family, to be brought back as bride, for any of the boys. Thus total strength of family is maintained constant.

(ii) A girl is married to the first cousin usually under the same roof. Even if they live separately it is considered no loss in terms of total strength of family.

(iii) Sometimes a girl is married on the condition that son-in-law will come and stay with bride's family for ever.

(iv) A large family, having more girls than boys, allows girls to be married without exchange of girls, so to say on loan, subject to condition that a girl born in the groom's family or a girl produced by this couple will be returned years later to the family loaning the present bride.

These are bases of rural poverty on which foundations of urban cities, great empires and civilisations were erected.

CHAPTER 6

THE PARTIAL BRITISH ATTEMPTS AGAINST IRRIGATED DESPOTISM

The old system of agriculture, as we know of under Mughals, was feudal despotism under which a government nominee, called by different titles but in effect a Jagirdar, was assigned one or more canals and lands towards his upkeep, maintenance of sepoys for law and order, collection of taxes and for payment of certain amount to the Central Government’s treasury. On this land were settled many petty chiefs or Zamindars or Waderas (literally meaning small chiefs), who in turn were responsible for management of water courses and distribution of water within their jurisdiction. The irrigation system before the British had always needed plenty of labour for excavation of new works, repairs, maintenance of old works and de-silting of canals, at least once annually. Such labour was kept at the disposal of the feudal lord by petty chiefs (Waderas), under his jurisdiction. To manage this properly the local chief had Kamdars (work controllers or foremen), who in turn were able to organise and draw upon free or force labour from among the cultivators of their lands. This team of free labour got only one free meal at noon during the working day, from the local chief. The labour force available free of charge, called Chher, was officially abolished by General John Jacob, the Acting Commissioner in Sindh, in 1856, but in reality continued in practice until thirty years ago. Even today it is used occasionally for de-silting of field watercourses.

The British assumed the power of chief or Jagirdar by the following methods.

- All land for which no water was available was considered government land.
- If the land could be cultivated, either by regular or irregular supply of water, it was leased Zamindar for a certain period or sold to him outright.
- land was leased out the allottee had to pay annual lease money and if it was sold out the allottee had to pay the cost as well as annual land revenue.
- If the government supplied water the allottee had to bear expenses for development and management of water, in shape of water rates charged every year.

The institution of Zamindari was not done away with. Zamindar's powers to exact forced labour from the cultivators, were curtailed but were not completely controlled. So much was the tyranny of the system that in 1918 AD, the Bombay Government had to set up a committee to enquire into "Rassai" "Lapo" and "Chher" in Sindh. Their four volume report runs over some 1500 foolscap paper (34 x 20 cms). The agency to develop and supply irrigation water was agro-managerial bureaucracy. Though it took over some of the functions of Jagirdar or feudal despot, it was not despotic in nature; primarily because it did not resort to the use of forced labour, nor did it exercise judicial and tax collecting powers. Moreover to maintain efficiency of the system distribution of water was made on equitable grounds to all landowners on a canal. This was an important social change and, according to Carl Marx, amounting to almost a revolution never heard of in Asia until British introduced it in the latter part of nineteenth century. The irrigation system so envisaged provided new possibilities for non-totalitarian development and these are still in evolutionary stage, but its remarkable achievement is gradual emancipation of the cultivator, during the past seventy years.

CHAPTER 7

THE CLIMATIC CHANGES IN AND CULTURAL DEVELOPMENTS IN SINDH AS WELL AS IN THE INDIAN DESERT; 9,000-1500 BC

The studies into climate of Thar desert, close to Sindh, have been based on the level of water in four inland salt water lakes in Rajasthan namely; Sambhar (27o N, 75o E), Didwan (27o-20’ N, 74o-35’ E); Lunkaransar (28o-30’ N, 75o- 45’ E) and Pushkar (26o-29’ N, 74o-33’ E) - the first two in the present semi-arid belt (rainfall between 25 to 50 cm), the third in the arid zone (less than 25 cm rainfall) and the last in semi-humid belt (rainfall 50-60 cm). The studies showed that:

- Before 9,000 BC, there was very dry climate.
- 9,000-8,500 BC, the climate moved form very dry to beginning of low wet period.
- 8,500-7,000 BC, climate changed to medium wet.
- 7,500-4,000 BC, high wet climate.
- 4,000-2,000 BC, high wet climate.
- 2,000-1,750 BC, very low wet climate.
- 1,750-900 BC, hyper dry climate.
- 900-400 BC, dry climate.
- 400-650 AD, low dry climate.

The present arid, semi-arid and semi-humid zones of Thar Desert were one step higher, i.e. semi-arid, semi-humid and humid zones respectively. This way the whole of desert zone is called Nara (desert of Sukkur and Khairpur districts and Khipro taluka).

Wet climate was an advantage to the man in domestication of cattle and ultimately led to domestication of agricultural crops in Thar, Kohistan, as far as Sibi and central Sindh. Bosi or Dubari cultivation thrives on preserved moisture in Jacobabad, Larkana and Shikarpur districts and Mehar and Khairpur talukas of Dadu district. This otherwise is a rice area, where water is appliedbetween June and September. By first August the latest, rising water table reaches the ground level, it starts falling gradually by October and in May it is already eight to twelve feet below ground level. "Dubari" grown on this land consists of peas, beans (Channa), oil seeds, barley and wheat. The first is harvested in February, the next two in March and wheat is harvested in April. Not every area is would be difficult unless rice is grown on it in summer and water table maintained at ground level until end of September. This means that rudimentary summer irrigation must have been practiced if vast areas were to be put under winter crop. It has already been discussed that the man in Sindh allowed depressions in the flood plains of the Indus to be filled in the inundation season and drained them in autumn to plant winter wheat since five-thousand-and-five-hundred years ago. The only exception would be riverine areas, which remain under flood water until September, and are drained automatically.

Possibility of such lakes existed along the Sindh hollow or possibly Makhi-Chotiari system of lakes and other small depressions specially in the lower Sindh, but scope was limited, looking to the extent and size of the Indus sites.

CHAPTER 8

WARM CLIMATE NEOLITHIC REVOLUTION, START OF AGRICLTURE IN SINDH; AND RISE OF CIVILISAITON; 7,000 TO 4,500 BC

Climate of Sindh has never remained the same and so has the prosperity. From 7,500-2,000 BC, it was a warm period and there was more rainfall. The River Indus was flowing full. Summer crops like millet, sorghum and rice were yet unknown, but water from the Indus was diverted to depressions and low lying lands and was drained out in October to cultivate winter crops; wheat, oats, oil seeds, vegetables and etc., on preserved moisture. The prosperity of raising crops led to the rise of Mehrgarh (7,000-2,500 BC), Amri (3,700 BC), Kot Dijji (3,300 BC) and Mohenjo Daro (2,350 BC). An un-interrupted civilisation lasting for some five thousand and five hundred years, and yet unparalleled, in Sindh existed.

The Neolithic period of human progress registers transition from hunting-food-gathering to farming as a way of life, thereby producing economic life with planned agriculture and animal husbandry. This first outcome of the transition is the settled life. From its beginnings, in the Crescent countries in south-western Mediterranean, Mehrgarh in the Indus plains and number of other sites in Asia, the transition spread to Europe and rest of Asia, gradually in a generalized pattern. Neolithic man had to clear forests for cultivation. By experience he arrived at slush and burn method of doing so. His tool for cutting the trees was the stone exe, which in Sindh was made from flint at Rohri, Ubhan Shah (near Kot Dijji) and mile 101 on National Highway, discovered by Bridget Allchin. Once agriculture was established, dugout trunks of trees were used as canoes for transporting the farm produce. By about 3,000 BC wheeled vehicles were introduced, though use of the wheel for making pottery was introduced at Mehrgarh around second half of fifth millennium BC or latest by 4,000 BC. In the first half of the third millennium BC large boats of 50 to 100 or even 200 tons, made from bundles of Sar grass, started plying from the Indus valley to Mesopotamia, carrying various kinds of articles of trade between the two countries.

Owing to well established rural economy, Neolithic farmers lived together in permanent settlements, which were shifted only when along with the village agricultural land attached to it was destroyed by natural upheavals such as change in the course of river, making it impossible to re-irrigate the land or when the land itself formed a low depression and became prone to frequent flooding. But as soon as the population of a settlement rose above the numbers that could not be supported from the land easily accessible, the excess population had to find a new settlement.

In general wheat, barley, peas, oil seeds and cotton etc., were grown and animals like cattle, sheep, pig, goat and ass were domesticated in these settlements. Rice, which was domesticated in south India and China, subsequently moved to the Indus basin areas in the beginning of second millennium BC, as is proved by its presence at Pirak. Fishing by means of hooks, harpoons, nets and traps was later development than agriculture. A fishing tool factory has been uncovered at mile-101 on the present Karachi-Hyderabad National Highway.

The lower Indus plains were suited to Neolithic environments, even more than Egypt and Iraq, due to peculiar regime and behavior of the Indus flowing on the ridge inundating a belt about 15-20 miles in width along both of its banks.

People of Sindh observed and intimately understood the annual behavior of River Indus from below Panjnad to the sea. It inundated vast areas in summer, depositing rich alluvium on which, without much effort, crops like wheat, barley, oil seeds etc., could be planted in fall and harvested the next spring. Women had invented agriculture and had used hand hoe. Labouring the whole season she could cultivate only two acres. They also found that with a pair of bullocks, yoked and used as draft animals, a man could cultivate four to five times more areas than a woman could, with hand hoes. Since man grazed cattle, he invented plough and yoke. In suitable areas he could produce more food than as food-gatherer or a woman as cultivator with a hoe. Thus the woman was relieved from agricultural production and lost freedom once for all, only claiming for herself her right to equality with man 8,000 years later. Burying of woman on husbands death or Sati is an outcome of this type of woman's slavery.

Geographical setting since Mehrgarh times
Hakra-Sarsuiti and Indus in Sindh
In the Mehrgarh period – 7,000 to 4,500 BC, Sindh had two independent river systems; the first being western tributaries of the Punjab (Jhelum, Chenab, Ravi, Beas and Sutlej) and two western tributaries (the Kabul and the Gomal rivers). Bolan, a minor tributary, which also carried its perennial water through Manchar Lake and Aral Wah to the Indus, was unimportant due to low discharges. Even the contribution of the Gomal was but trifling. The second or the eastern system was the Sarsuiti-Drishadvati-Hakra, discussed in appendix- III.

The seven river system, the center of so called Rig Vedic tribes' activity, consisted of five rivers of the Punjab, the Kabul and Indus itself. The area below the Panjnad was called, and could well be so, the "Sapta-Sindhu". As late as 1644 AD the Indus itself below Panjnad was called "Haft Darya" or "the seven rivers", as is stated by Mirak.

Ptolemy’s (150 AD) seven rivers are the same as Mazhar Shah Jehani’s, except that Ptolemy brings in his system Swat instead of Sutlej. In early historical times the seven rivers of the Indus system were called its seven mouths. The Sapta-Sindhu area most probably consisted of parts of Bahawalpur and Sukkur divisions, situated on the left bank of the River Indus. The sacred river of Rig Vedic tribes was Sindhu, which stood on equal footings with Matra, Varona and Dyauses; their gods. The Ganges became holy after 500-400 BC.

There is hymn in the praise of the Indus in the Rig Veda. They sung the glory of the Indus at that time (800 BC), when Indus below the Panjnad was the most productive area in the South Asia and possibly in the whole world, then known.

The eastern river system, a historical mystery until the thirties of nineteenth century, was covered mainly by the river Sarsuiti, as the lost river of the Great Indian Desert. Of many investigators of this river a few noteworthy are: Pottinger, Burnes, McMurdo, Scott, Baker, Fife, C.F. Oldham, R.D. Oldham, Haig, Raverty, Minchin Barnes, Cousens, Whitehead, Stein, Pithawalla, Lambrick, Bimal Ghose, Amal Kar & the present writer. After extensive research of a century and half it was concluded that the Hakra or the Eastern Nara was the original bed of the river Sarsuiti during Pleistocene and later on it was being supplied by rain fed streams like Thaghar, Thangri, Drishadvati, Rainee and Markand. Spill water from the Sutlej also supplied water to the Hakra in every inundation season and so did the Indus between Panjnad and Bakkar.

These findings have been summarised in "Ground Water" (1964) and continued further work with the help of aerial photographs, which has shown clear connection between the Eastern Nara (Hakra) and the Sarsuiti. Geographers Holmes and Wilhelmy and archaeologist Rafique Mughal (1973)0 have carried out further work discussed in Appendix-III.

It is now fairly clear that the Sarsuiti-Hakra was an independent river system during Pleistocene. Water started reducing in the second millennium BC due to titanic movements and as a consequence old Indus civilisation settlements namely, Kalibangan, Hastinapur, Alamgirpur, Bahadurabad, Bhoot, Badrakali, Fatehgarh, Munda, Hamayungarh, Dulman Bhawar, Budopal, Rangmahal, Kaiser, Suratgarh Sardargarh, Sohakot, Bijaingarh Ramsinghpur, Hakra, Sandhanwala, Marot, Kudawale, Lurowala, Borwar, Anufarh, Phulra, Mirwah, Managarh and Dingarh started decaying. These sites belong to the Bikanir and Bahawalpur area and not to the present Sindh. Sindh's contemporary sites have not been yet examined. However the system kept operating with ever reducing supplies. At the time of Alexander's conquest of Sindh (325 BC), it may not have been a non-perennial system flowing mostly in summer season, yet supplying enough water below Jamrao head in that season to help raise short season Kharif crops. During that season it may have been navigable too. Its supplies further reduced in time and by the beginning of thirteenth century, it dried up completely.

Gabarbands

It was probably during the Amrian storm that Gabarbands were constructed in Kohistan. They were not water storage dams, but water diversion dams.

They acted as weirs and diverted part of thunder water into adjoining lands, which were given properembankments along the contour lines to hold and retain about twenty to thirty inches of water column for a few days, to allow water to soak into the ground. Thus on preserved moisture a crop of grains and oil seeds etc., was raised. The period of around 4,250-3,800 BC shows decline in rainfall and this may have needed construction of Gabarbands both in Sindh and Balochistan.

Dimensions, foundation materials, construction details and suggested functions of Gabarbands at Phang Nai in Kohistan.

Structure	Length (m)	Height (m)	Best Width (m)	Top Width (m)	Function	Construction details (volume-m^3)	Function
South	100	3	8	3	Sandstone outcrop	Dry uncut rock on sandstone outcrop (1650)	Low-head weir; primary hydraulic control
East	126	7.8	30	7	Conglomerate outcrop	Double lift, earth fill core, upstream and downstream dry uncut stone facings (43,340)	Block water gap in hogback ridge and divert flows to the south dam
North	136	4.2	8	3	Alluvium	Single lift, earth fill core, upstream and downstream dry uncut stone facings (2,650)	Block northern end of strike valley
West	75	3	10	3	Alluvium	Single lift, earth fill core, upstream and downstream dry uncut stone facing (1,350).	Trap coarse sediment during flood flow events
Spring	35	2	7	2	Conglomerate outcrop	Dry uncut rock on conglomerate outcrop (315).	Low-head weir for diversion of spring flows

The remains of such Gabarbands are found in vicinity of Kohtarash, Gozo Nai (30 miles north of Kohtarash in the upper valley of Naing Nai) and between Sita and Trapan Nai in Kamber taluka. Harvey and Flame have explored these sites on the Baran Nai, already reported by Lambrick, Mujamdar and others. Dimensions of these are given in table attached and the cross section and plans show the ingenuity of the man and his understanding of hydraulic forces, the structures had to withstand. Gabarbands are also discussed in chapter 10.

Table attached gives the engineering dimensions of Gabarband at Phang.

Springs as a source of Irrigation

Soon after rise of Mehrgarh, man in Sindh used spring water for raising crops. Present writer has located forty three springs in Kohistan, of which at least half supported irrigated agriculture until at least 3,000 BC, specially when rainfall between about 9,000 to 4000 BC was two-and-half times what it is today. Some springs like Naing, Wahi Pandhi, Damb Buthi, Taung and Kai support irrigated agriculture even today. Beginning of irrigated agriculture goes to springs first, followed by Gabarbands. Irrigation from springs, which flowed year around in a small stream, was easily utilised for raising crop and is a definite proof of its introduction before Amrian times. Irrigation from the Indus itself is a development dating back to Amrian times (3,500 BC) in the form of filling depressions and draining them for cultivation and use of Wahur, Dhoro and Dhori, a rudimentary type of irrigation.

Consequences of Agriculture
The consequences of food production were revolution in itself and are discussed in paragraph below:

Production of more food than the family needed, resulted in the overall surplus, which was utilised in feeding and raising artisans, traders, bureaucrats and priests and above all the despots, who controlled and rationed the means of agricultural production i.e., the land and water.

This in turn led to the rise of State for recovery of part of farm produce, and also need for keeping records, for which arts of writing and mathematics were invented.

It resulted in freeing some people from agriculture, who built big settlements towards cities, further causing growth of urban life leading to development of culture including trade, arts and crafts, luxury goods, means of storage and of transport and communications etc.

This was to be followed by further inventions and discoveries connected with further development and improvement of irrigation system; its security and maintenance, control and distribution of water supply to individual farms as well as individual farmers for obtaining higher production of food grains to meet requirements of agriculturists, as well as those of non-agricultural rural or urban population.

Imposition of slavery, involving vast masses of people, was bound to agriculture so that the needed high production could be ensured. This mass slavery of the land tillers continued in all the ancient irrigated parts of the world including the Indus valley for the next 5,500 years i.e., to this day and not as boughtout slaves, but creating caste system by various methods to keep them socially inferior, economically poor and attached to the land. Absconding of tillers from land was discouraged except when they were surplus. Absconding tillers are returned to the original land owners even now by an unwritten law observed by all other land owners, by use of force.

The fact that almost all the known pre-historic mature Indus culture sites in Sindh are located in the proximity of modern villages of irrigated area, indicates ancient’s similar dependence upon identical water and soil resources as of today's rural population. The principal forest trees Babul (acacia arabica), tamarisk gallica and dioica and Kandi (prosopis spicigeva) are main sources of local fuel today, as they had been for centuries.

Evolution of crops in Sindh

The domestication of crops and animals started in Mehrgarh in the following sequence:

7,000 or 6,000 BC; The cereals cultivated and animals domesticated were: Naked (sphaerococcoid) barley, 6 row barley (Hordeum vulgare), wild barley (Hordeum vulgare varinudum), Einkorn and Emer (Triticum dictum wheat). Domestication of cow and buffalo followed with a gap of some centuries by domestication of sheep and goat.

6,000-5,000 BC; Introduction of Durum bread wheat, peas (pisum orvonse), about 3,000 to 3,500 before their presence/introduction at Mohenjo Daro, dates (phonex dolylifera), more than 3,000 to 3,500 years before Mohenjo Daro and oil seeds (sesamum and mustard), about 3,000 to 3,500 years before Mohenjo Daro - around 6,000 to 5,500 BC.

4,500-4,000 BC; Cultivation of cotton for fibre and probably oil. New variety of wheat (triticum aestivum) introduced. Naked wheat (sphaerococcoid) introduced soon after 4,000 BC.

Inheritance of life pattern of Neolithic farmers from hunter-food-gatherers (14,000-9,000 BC)

Table below shows the life pattern of hunter-food-gatherers.

Houses	Tents from skins of animals
Bed mattresses	Skin fields with straw and feathers
Life expectancy	28-32 years
Women produced 3-4 children at age of:	18, 22, 26 and 30
Number of animals slaughtered per year per adult	13-Dec
Hunting band size	30-40 peoples

Neolithic changed the above patterns in the following ways: mud houses with thatched material and wooden roof and use of fibre for clothes and mattresses. Life expectancy increased. Due to intake of more carbohydrates women gained weight and more than 10 child births during her life became possible. Five acres of land could support a family of eight. Sizes of villages increased to a few hundreds in beginning and to a thousand or more, later on.

Cooking vessels

Life was not easy for the Neolithic or even hunter- food-gatherers. The cooking methods and vessels used from 10,000 years ago to 6,000 years ago, listed below, show the type of drudgery for women whose duties included cooking for the whole family.

Years ago	**Vessels for cooking**
10,000-9,000 years	Open hearth and roasting
8,000 years	Cylindrical burnt clay pots were used. Heating was done by immersing hot pebbles and burnt clay pieces into food being cooked.
7,000 to 6,000 years	Semi-spherical bottom clay pottery on clay tripods introduced

Earliest known pottery came from Catal Huyuk around10,600 years ago a gap of 2,500 years with Mehrgarh.

Springs in Sindh

S. No.	Name of Spring	Co-ordinates	Water discharge (litres/sec)	Quality salts (ppm)	Area irrigated (acres)
1	Ghazi Shah, Johi taluka (Thermal)	26°-27' N, 67°-30' E	85	770	450 Fresh
2	Phadak, Johi taluka		70	Fresh	350
3	Wahi Pandhi, Johi taluka	26°-41' N, 67°-30' E	-	Fresh	250
4 to 7	Four Gaj springs, Johi taluka	Upstream of Gaj	-	Fresh	-
8	Tando Rahim (Thermal)	26°-30' N, 67°-30' E	-	-	-
9	Pharoti, Sehwan taluka	26°-6' N, 67°-43' E	30	450 Fresh	-
10 & 11	Kai (twin springs), Sehwan taluka	26°-15' N, 67°-42' E & 26°-16' N, 67°-41' E	85		
12 to 14	Naing (triplet spring), Sehwan taluka (Thermal)	26°-17' N, 67°-32' E and 26°-18' N, 67°-31' E	85	Fresh	500
15	Bonjo, Sehwan taluka (Thermal)	26°-8' N, 67°-47' E	70	800 Fresh	350
16	Dhal, Sehwan taluka	26°-04' N, 67°-47' E	5	Slightly saline 1050	20
17	Bhat Dhoro or Lahri Dhoro, Sehwan taluka	26°- 3' N, 67°-39' E	5	Fresh 500	
18	Gorandi, Sehwan taluka (Thermal)	26°-26' N, 67°-30' E	8	Fresh	50
19 to 21	Laki (triple springs), Kotri taluka (Thermal)		18	Brackish	-
22	Ranni Kot, Kotri taluka (Thermal)	26°-07' N, 67°-58' E	15	Slightly saline 800	50
23 & 24	Khajur, Mahal Kohistan taluka (double springs)	25°-42' N, 67°-47' E	-	Fresh	-
25	Dhorogar, Kotri taluka	35	8	Fresh 650	-

S. No.	Name of Spring	Co-ordinates	Water discharge (litres/sec)	Quality salts (ppm)	Area irrigated (acres)
26	Karogari Kotri taluka	35	15	Fresh	-
27	Ali Murad, Mahal Kohistan taluka	26°-31’ N, 67°-26’ E	3	Fresh	10
28	Karachat, Mahal Kohistan taluka	25°-45’ N, 67°-44’ E	15	600 Fresh	500
29	Pokhan, Kotri taluka.	25°-49’ N, 67°-45’ E	15	900	
30	Ratan Shah or Taung	25°-45’ N, 67°-35’ E	15	Slightly saltish 1050	80
31	Jim, Kotri taluka (Thermal)	25°-46’ N, 67°-36’ E	15	750, Fresh	-
32	Khair, Kotri taluka		5	-	-
33	Jasia, Kotri taluka				
34	Kohtrash or Ghaibi Pir, Kotri taluka	25°-42’ N, 67°-37’ E		Slightly saltish, 1120	500
35 & 36	Hikebroo and Gabar (twin Springs) Kotri taluka	35 0/10 Grid C 664 903	3	Saline 2000-2300	-
37	Koshra jo Wahro, Kotri taluka (Thermal)	26°-0’ N, 67°-48’ E		800, Fresh	
38	Garam Aab, Kotri taluka (Thermal)	26°-13’ N, 67°-42’ E	-	800	
39	Kandar, Kotri taluka (Thermal)	26°-14’ N, 67°-35’ E	-	Slightly saline	-
40	Bibiji Bhit, Kotri taluka	26°-0’ N, 67°-20’ E	-	Slightly saline	-
41	Arab jo Thano	25°-38’ N, 67°-50’ E	-	Fresh	-
42	Shah jo Kotrio	25°-36’ N, 67°-51’ E	-	Fresh	-
43	Ahmed Shah	25°-38’ N, 67°-71’ E	-	Fresh	-
44	Osman Buthi	25°-32’ N, 67°-49’ E	-	Fresh	-
45	Bachani, Kotri taluka	25°-29’ N, 61°-53’ E	-	Fresh	-
46	Jein Pir, Thatta taluka (Thermal)	25°-00’ N, 68°-03’ E	-	Slightly saline	-
47	Manghopir, Karachi West (Thermal)	24°-39’ N, 67°-06’ E	-	-	-
48	Manghopir Shrine, Karachi West	24°-37’ N, 67°-06’ E	-	-	-
49	Khadeji Falls, Karachi North	-	-	-	-

Potters wheel made semi-spherical bottom pottery possible and its production on mass scale and very cheap. Potters wheel was known in Ur (Iraq) in 3,250 BC and it may have been invented at Siyalk-III earlier. It was used at Mehrgarh around 4,000 BC, but in Sindh sites first evidence comes in Amrian times around 3,500 BC. At Kili Gul Muhammad, near Quetta, it is dated as 3,600-3,300 BC.