10. Reappraisal of Water Management System in Indus Saraswati Civilization

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Abstract

The Harappan Civilization, also known as the Indus Valley Civilization (c. 2600–1900 BCE), is renowned for its advanced urban planning and hydraulic engineering. This study offers a reappraisal of the Harappan water management system, examining both the archaeological evidence and recent research insights. By analyzing features such as dams, wells, drains, reservoirs, baths, and sophisticated sewage systems found at key sites like Mohenjo-daro, Harappa, Dholavira, and Lothal, Banawali , this paper explores how the Harappans adapted to diverse ecological zones and managed water for domestic, agricultural, industrial, commercial and possibly ritualistic purposes. Special attention is given to the role of topography, settlement layout, and material technology in sustaining water efficiency and sanitation. This reappraisal not only highlights the ingenuity of Harappan engineering but also provides insights into sustainable water practices relevant to modern environmental challenges.

Introduction

In the western part of the Indo- Pakistan Sub- continent there was a plenty of fertile land. This region was watered by the Indus and the Saraswati Rivers and with sufficient rainfall. The Harappan people grew wheat, Barley, Cotton, rice, garlic, etc. and their surplus food grains were stored in the granaries (Possehl 2002: 64). The Harappans mostly depended on the alluvial soil and probably they used canal water for irrigation. The monsoon has been an uncertain factor in the Indo-Pakistan subcontinent since very early time. Some evidence of a 'V' shape channel for 40m has been found at Barar in Rajasthan. A moat around the Harappan settlement was exposed at Banawali (Fig.1) during excavations (Bisht 1999:20).

The dock at Lothal was also connected with river by a canal (Bhogavo). In Harappan city settlements the water was an important commodity for them (Joshi 2008:123) based on the local geography, wells and reservoirs were constructed inside the cities to provide drinking and bathing water.

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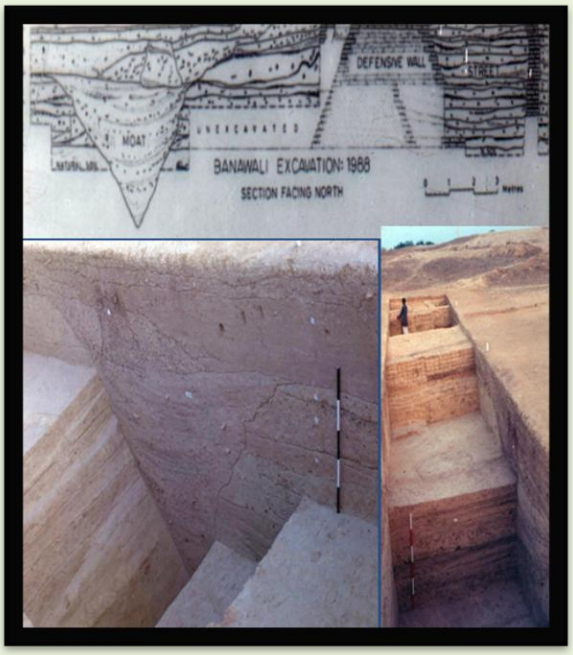
Many wells were dug at Mohenjo-Daro and kept in working order for hundreds of years. These 10 to 15 m deep wells were lined with specifically constructed wedge-shaped bricks to create a structurally

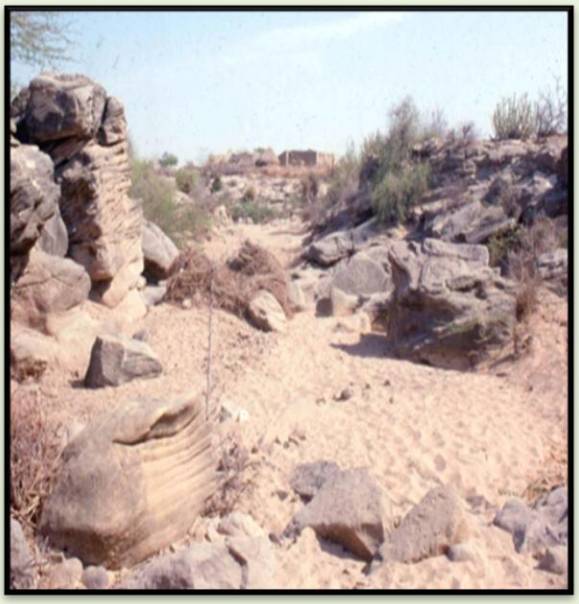


(Fig.1 Banawali V shape Moat , courtesy: Archaeological Survey of India)

sound cylinder that would not collapse under pressure from the soil surrounding it. Deep grooves on the bricks near the upper edge of the well indicate that ropes were likely employed in conjunction with leather or wooden buckets to lift the water out (Kenoyer 1998:59). At Mohenjo-Daro, the majority of homes or blocks of homes had at least one private well, and many communities featured public wells along the main roadways for visitors and the locals, few wells were also discovered in Harappa, Lothal, and Dholavira. According to Michael Jansen's estimation, Mohenjo-Daro may contain approximately 700 wells (Jansen 1991:75–81).

Water Management for Agriculture Purpose: -

Water management was a specialty of the Harappans. Harappan agriculture was dependent on the monsoon, but they built canals to increase productivity and protect their crops from unfavorable weather. In order to use the rainwater for irrigation, they also built a hydraulic device to collect it. At several locations, some evidence such as dams, canals, and reservoirs were discovered.



(Fig.2 Dholavira stone dam across the Manhar, courtesy: Bisht,1999)

Harappans settlement at Dholavira is situated between the two seasonal rivers Manhar and Mansar, which empty into the Great Runn of Kachchh. The catchment area for these two rivers lies about 10-12

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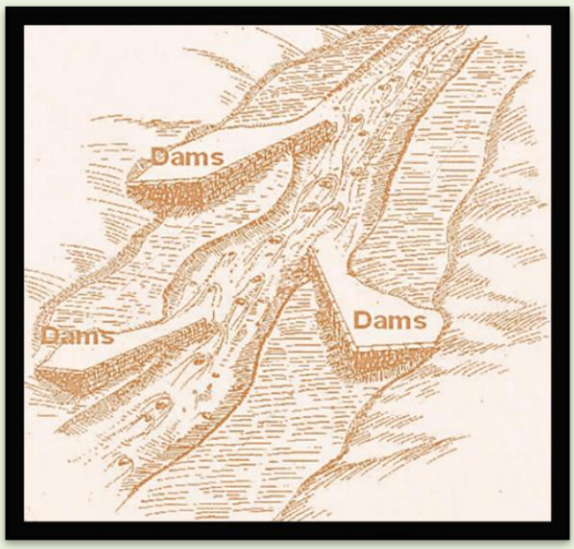
km away in the hills that are about 100-150 m high on the eastern periphery of khadir. Both the rivers have a high gradient of 3-4 m per km, and the high velocity gushing water was checked by putting across boulders at various places. Three check dams near the site have been made across the river Manhar (Fig.2) with rubbles and masonry stones.

The water was diverted to the reservoirs in the city. On the Mansar a dam has been built which fed the large area of the city for agricultural purposes. The Harappans successfully dammed the river waters of the Manhar and the Mansar at intervals across various points. The dams were constructed where the river span was relatively narrow (Fig.3) (Joshi 2008:120).



(Fig.3 Artist Reconstruction Dam, courtesy: Bisht,1999)

This resulted in a series of check dams which were conducive not only to diverting rain water of rivers into the reservoirs of the city but also for holding sweet water back in the river so that the sub soil water table of the area rises and gets sweetened for agriculture and other habitation purposes. The ground water of the region is otherwise relatively hard and brackish, which gets worse with each passing year if rains fail (Bisht 1999:27). One damming point on the Mansar and three on the Manhar can still easily be seen on the ground. The points on the Manhar appeared to be inside the eastern fortification creation of check dams at narrow openings along the river course was feasible with the minimum human effort. It seems that a wall of big and small stones, held in place with the help of natural features and upright wooden logs was provided at such points (Bisht 2000:20). Adequate measures must have been taken in creating check-dams or else the violent flow of rain water in the river, which swells in no time after the torrential rains, would sweep away any loose thing down the course of the river. It seems that the Harappans at Dholavira first settled by the side of the Manhar and built their citadel (Joshi 2008:122). As the settlement grew in size and also in population, an inevitable need might have felt by the early and mature Harappans to harvest more water from the other sources as well, for which they dammed another neighborhood channel called the Mansar that flowed

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almost east-west on the northern fringes of the ancient settlements. It seems that the Harappan at Dholavira made some small channels to divert the water of the Mahar and Mansar for irrigation and domestic use. They constructed reservoirs and some other hydraulic structures to collect the river water. The Harappan people at Kunal constructed a water cannel for irrigation. The 'V' shaped water channel was constructed around the habitational area. The maximum depth and width of this channel was 3.45m and 4.15m from the top respectively. The channel also may be for the protection of settlement. (singh 2012:120)

Water Management for Commercial Purpose: -

Building an artificial dock for berthing ships was the biggest contribution the Lothal engineers made to the advancement of science and technology (Fig. 4). The largest cargo-handling facility ever created by the Harappans or by any Bronze Age culture, it is the oldest dock in the world and was also the most scientifically designed after taking the current's force, direction, and water thrust into account, among other factors. The Lothal dock was significant because it had a novel water locking device that was installed in the spill route and could be opened or closed depending on the situation (S.R. Rao 1973:70). It prevented the basin from silting up while controlling the flow of water during high tide and ensuring that ships could float during low tide.

(Fig.4 Lothal Dockyard Artiest Reconstruction)

To reduce the risk of flooding and silting, it was not constructed on the main thoroughfare (S. R. Rao 1979:72). It was built in the east of the city. Its western embankment wall was 716ft. the eastern 705ft.6Ins, the southern 117ft and the northern 123ft.in length. The width of the wall was 6ft. at the foundation level in the case of the western arm and 5ft. in other cases and the top it was 3ft. 6 ins. wide it. (S. R. Rao1979:73). The extant height of the wall in the south west corner of the basin was 11ft. with 42 courses of bricks. Originally, the wall must have been raised upto the top of the mud brick platform abutting the western embankment thus accounting for a total height of 14ft. (S.R.

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Rao 1979:63) including 3ft. in the foundation. Sea going vessels could enter the dock at high tide through a 12meter-wide inlet built into the northern embankment. At the opposite end a channel, 1 meter wide, was constructed for allowing excess water to escape at high tide (Rao 1973:72). In 2000 B. C. the river (ancient Nullah) flooded the city and the dock. The river silted up its original flow channel and started flowing 2 kilometers east of city with the result that the ships could not find easy access from the sea to the dock then a new channel was made to connect the ancient Nullah, (Bhogava), so that the ships could access to the dock by a 23 ft. wide inlet in the eastern wall and two projections (4 ft 8 ins. wide) were also made one on either side of the inlet (Rao 1973:72). These projections seem to retaining walls of a mud bund flanking the artificial channel connected with the inlet. A mud- brick platform, 800ft long and 64 to 72ft. wide, was also constructed to the west of the dock for easy hauling of the cargo. Sometime monsoon water enters the dock through the inlet (Rao 1979:73) and continued to be in its use upto 2000 B.C. The public drain which discharged sullage water into the dock through an opening in the western embankment was closed by building up a brick wall (Rao 1973:73). Thus, original inlet in northern wall had ceased to function in 2000 B.C. the flood in circa 1900 B.C. was of such long duration and great intensity that the entire dock was destroyed along with the township. The dock constructed at Lothal had great importance. It was constructed to develop the trading activities with other contemporary civilizations. The Harappan people produced surplus foodgrains and other goods so that they could increase their earning by exporting the goods. The existence of dock at Lothal and Goha indicate the sea route trade of the Harappan. The ancient dock at Goha was very small in size than Dock at Lothal. It was half of the length of the Lothal Dock and only one quarter of its width. It was not used at large scale by the people for trading activity. Goha was not a big trading center like Lothal during Harappan period.

Water Management for Public Ceremony: -

In the SD region of Mohenjo-Daro, Great Bath is situated to the east of the granary. On the high region, it was built. It is the oldest water tank in ancient world. Mohenjodaro is referred to as the "first swimming pool" by some visitors. The tank has an overall length of 11.7 meters, a width of 6.9 meters, and a maximum depth of 2.4 meters. One from the north and the other

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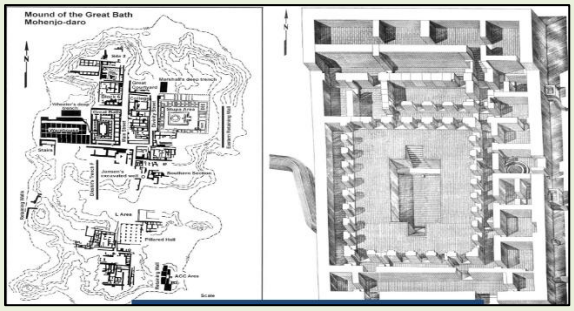
from the south, two large steps descend into the tank (Joshi 2008:127).



(Fig.5 Mohenjodaro Greath Bath courtesy: R.S.Bisht)

Wooden plants or treads might be placed in the little sockets at the edges of the steps. There is a little ledge with a brick border that spans the whole width of the pool at the bottom of the steps. Coming down the stairs, people could walk around the edge without entering the water. Due to well fitted bricks that were installed on edge and plastered with gypsum, the tank's floor was watertight. The side walls were built in a manner that was comparable as well. A thick layer of bitumen was applied to the walls of the tank and maybe even beneath the floor to further increase its water tightness. The south-west corner of the room has a sloped floor and a little outlet leading to a brick's drain. (Kenoyer1998:64) This small drain first passes through a large rectangular space that was originally covered with wooden beams and then through a corbelled arch drain that curves along the edge of the northern terrace of the granary (Joshi 2008:127).

A detailed analysis of the symmetry of the building and compartment with other buildings has led Michel Jansen to suggest that the architects who designed and constructed these buildings and water tank were constrained by the limited area between the main north-south street and the granary (Jansen 1991:81) On the eastern, northern, and southern margins, brick colonnades were found, while the western side was absent owing to mound erosion. From the south and east, two substantial doors opened into the building. Along the building's eastern perimeter, there are rooms. A well that may have provided part of the water needed to fill the tank was located in one of the rooms. Although no inflow drain has been discovered, rainwater may have been gathered for the same purpose. Because there is a large structure with eight modest rooms and more basic bathing platforms to the north, the complex building was only used for public bathing. The majority of academics concur that this tank had important religious purposes.

Water Management for Domestic Purpose: -

The distribution zone of the Harappan sites falls mainly in a semi-arid region, even though there is simple evidence that thMid-

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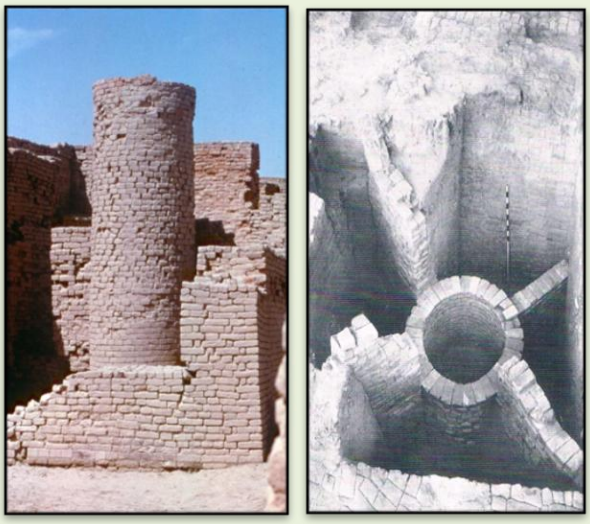
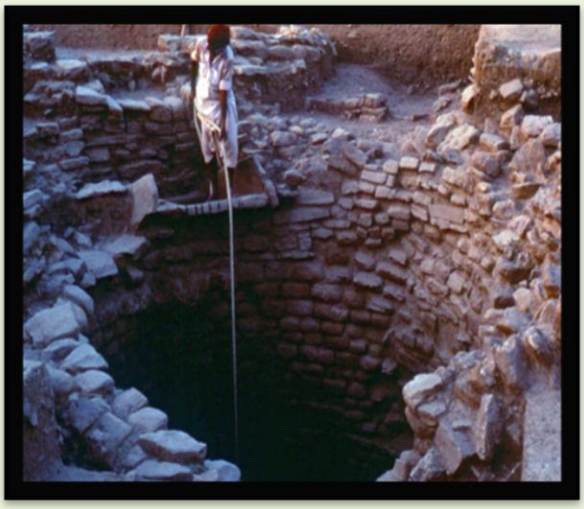
Holocene was a bit wetter than today, so the Harappans paid due attention to water



(Fig.6Mohenjodaro and Kalibangan well courtesy: R.S.Bisht)

harvesting, by using underground water, rain water and river water. Wells were the main source of pure water for them. At Mohenjo-Daro numerous wells were dug throughout the city and maintained them for hundreds of years. When the early



(Fig.7 Dholavira well, courtesy: R.S. Bisht)

excavators had cleared some of these wells, they once again began to fill with water, although much of the groundwater around the site is quite brackish (Agrawal 2007:139-40). These 10 to 15m deep wells were lined with specially made wedge - shaped bricks to form a structurally round cylinder (fig.6).

On the top edge of the well there are grooves on the bricks indicating that water was probably drawn out with leather or wooden buckets. Possehl guesses that well in private houses at Mohenjo-Daro and Harappa were probably built by people living in these houses and not by the administration (Possehl 2002:57-58). The wells were available for drinking water both in residential and citadel areas at Mohenjodaro, Harappa, Lothal, Kalibangan, Dholivara and Banawali. These wells were not very large and could be operated by one or two persons.

The well at Dholavira is the biggest among the Harappan cities which could be operated by one or two persons. Its trough also bears rope marks suggesting the lifting of water probably in leather bags with the help of a horizontal bar on the side wooden pillars, they draw water by using a pulley and throwing it in the drain which carried the water into adjacent reservoirs in the castle area. There were two types of well in the Harappan settlements., which were used by people (Agarawal 2007:140) public wells including piau where two or more

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pots are kept by the side of the well and the room wells which were used by the house (Fig.7).

It appears that well water was used for drinking and river water was used for all other purposes. Some sites were away from the river then the well water was used for all purposes. There were public wells for both people and animals in several neighborhoods along the main roadways. A private well was present in the majority of homes at Mohenjo-Daro. The city of Mohenjo-Daro is known as the "city of wells" because

of the estimated 700 wells that may have existed there (Janren1987:220), compared to the 30 wells that Harappa may have had based on the number of wells that have been discovered during excavations there. According to Kenoyer, Mohenjo-Daro was likely located far from the Indus River and saw less winter raindrops than the other city, which might have been the difference between the two. At Harappa, a sizable dip in the city's center could have been a sizable tank or reservoir that was open to the city's residents from all of the different neighborhoods. There are just a few wells in Dholavira, Kachchha, and the majority of the city's water supply is stored in sizable stone-lined reservoirs during the rainy season (R.S. Bisht, 1999:29). The well's top would have been elevated above the ground in Harappan towns, and a tiny drain would have been present almost to prevent unclean water from returning to the well. Wedge shaped bricks were used in the construction of the wells. The ground was supported by the bricks, which also served as protection against erosion and cave-ins. Additionally, clear, sweet water with a minimum of silt and other big particle impurities is delivered through brick-lined wells. Even on a river-floodplain, well-constructed and maintained brick-lined wells may provide crystal-clear water. Wells were expanded with additional brick courses as the city mound increased. In the Lower Town at Mohenjo-Daro, the area supplied by each well and the mean distance between wells are extremely stable. During the time that people lived in cities, a few wells were abandoned. (J.P.Joshi 2008:114) At Mohenjo-Daro many private wells has been exposed by the archaeologist. In a section of DK area, a well was found with its internal diameter 4ft. 3 ins. The steening of the well had been raised during the succeeding period. Its coping which was grooved by the ropes used to pull the water jars. The wedge-shaped bricks used to build the coping had been cut from ordinary molded bricks measuring, 10.73 ins. long by 5.25ins broad. The bricks were laid on their edges,

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the broad faces having been kept away and not the sides. A neatly laid pavement

(Fig.7 Dholavira Soakage jar, courtesy: R.S.Bisht)

surrounded the well, but it had collapsed at some later date through subsidence (Possehl 2002:105) Deep hallows were exposed here and there in the pavement where the water jars were kept. (E.J. H. Mackay1998:109-14) The split water drained away through an opening (6.5ins. wide by 8.5 ins. High) to a roughly circular soak pit (Fig.8).

(Fig.8 Banawali Bathing and cloths washing platform, courtesy: R.S. Bisht)

It is 5 ft. in diameter. The walls of this well chamber and the soak pit were of both pavement and coping, this well was in constant use, perhaps by the potters who used the adjacent kilns, as well as for ordinary domestic purpose. A well was found in a room in DK area. Its internal diameter was 2ft. 2ins. It was a private well and was in use during Harappan phase. The wedge-shaped bricks (10.9ins. ×4 to 5.6 ins. ×2.5ins.) were used in the coping of the well. These bricks were not accurately fitted together and give the impression that they were originally intended for a well of larger diameter. (E.J. H. Mackay1998:89-91) In DK Area at Mohenjo-Daro, a well was exposed. The internal diameter of this well was 3 ft. The coping of the well was raised a few inches above the ground level and carefully bordered with bricks set on edge to prevent split water soaking into either the well coping or the walls. In the construction of well the large size mud bricks (14.35×7.25×3.62 ins.) were used. (Mackay1998:93)

At Mohenjo-Daro, a well in good state of preservation was found in a house in DK area. The well was having 2ft 2ins internal diameter. In the coping of well some large size wedge-shaped bricks (11.5×3.75×2.5Ins.) were used. The coping of this well was in good condition. The coping stood 1ft. above the upper pavement, whose bricks measured 9.6×4. 6×2.4ins. A very sloping water chute in the thickness of the outer wall drained this well-room into the first street. The well was

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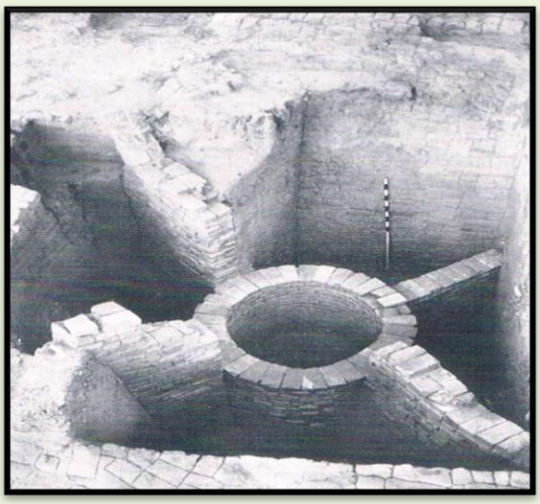
used by the dwellers of the building. (E.J. H. Mackay1998:71) In DK area a well was exposed in a room of a house. (E.J. H. Mackay1998:58) The internal diameter of



(Fig.9 Kalibangan radios well, courtesy: R.S.Bisht)

the well was 2ft 10ins. The molded wedge - shaped bricks (10.25ins×3.5ins×2.25ins) were lined in the construction of the well and mud mortar was used in the lying of the bricks. A well was found in a house of G-section at Mohenjodaro which has 2 ft internal diameter. The well was in good preserving condition.

It was publicly used. The well is having a border of bricks along its sides (Mackay1998:72-73). The bricks 10.75×5.25×2.5ins were used in the construction of the well and its coping. A great building of G section contains a well in the northeast corner. Its diameter was 5 ft 5ins. There were no signs of any entrance from outside, the steening and the surrounding pavement were raised from time to time to keep this well in use. The addition to the steening built with the usual wedge shape bricks, 10.7×5-5.4×2.5 ins.

Mackay1998:150) In SD area a well near the south-eastern corner of a building was found. Its outer and internal diameter was 6ft 2ins and 4ft 3ins respectively and it was well preserved. Coping was constructed with wedge-shaped bricks (10.9ins long, 5.4ins wide, and graduating in thickness from 1.75 to 1.85ins). The bricks used by the Harappans were 9.75×5.15×2.25ins in size and were laid in mud-mortar on their longer edges. Some 2.75ins high edging around the well is to pre vent the percolation of water into the walls. An open channel, 0.29m wide and 0.20m wide and 0.20m deep, was used to take the waste water of the room into the public drain in the street. (Agrawal 2007:104) This is a finest example of a room well at Mohenjodaro. However, this appears to be a public well because it had an entrance of 2.87m in the street which shows that it was used by the public for a long time. A well with very interesting features was found at Kalibangan. Its internal and outer diameter was 1.25m and 1.85m respectively. The ring of the well was 30 cm. in width. (Bisht 1999: 29) It was constructed with wedge - shaped bricks and was found supported on four sides by four radial walls of a single brick course. (fig.9) Mud mortar was used

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in the laying of bricks (30×15×7.5ins). The well has suffered heavily at the hands of the brick robbers. This well catered to the needs of the people who were bathing on the bathing platforms in the citadel area (Agrawal 2007:96). The largest well, made of dressed stone is found at Dholavira in the south-western corner of the castle. It has a diameter of 4.45m in the north-south direction and 4.15m along east-west. The well has been excavated upto a depth of 13.60m. The basal slab of the trough has deep rope marks.

. It is considered that masonry pillars had a wooden Horizontal shaft fitted with on

(Fig.10 Dholavira well, courtesy: R.S.Bisht)

pully as indicated by the huge debris on both the sides (Fig 10). The south-western quadrangle of the citadel had a water structure, a stepped tank with a feeder channel issuing from the well (Bisht 1999: 29). This is a remarkable well connected with a tank reservoir for collection of water with the aid of some sort of large leather begs. The pulling of water and empted it into the reservoir could be a regular exercise. This is a very earliest example of pulling water in reserve for domestic purpose. Similar method might have been used for agricultural purpose also (Joshi 2008:118). There were two tanks near the well, one larger and the other smaller lying 4.70m apart. The (Fig.10 Dholavira well, courtesy: R.S.Bisht) internal measurements of the larger tank was 4.65m north -south, 3.15 east-west and 4.80m deep. The tank has six steps having a tread. There was a miniature square platform of 80cm square near the tank (Fig.11). The floor of platform bears the wear marks of the jars. The measurement of smaller tank was 2.20m north -south 2.30m eastwest and 4.85m deep. In one of the corners there was a flight of steps. The staircase is 5.30cm long and 2.45cm wide having fourteen steps. Close to the last step, there was a slab covering an aperture, which may be connected to a Limestone drain that might have been used for letting out the dirty water during periodical mopping of the tank. (IAR1996-97:16) The large tank appears to have been a storage tank and the other was for bathing purpose. At Lothal the main source of drinking water to the residents in the Acropolis and Lower town was the well (Joshi 2008:116-118). A well, was found in the Acropolis area near Street

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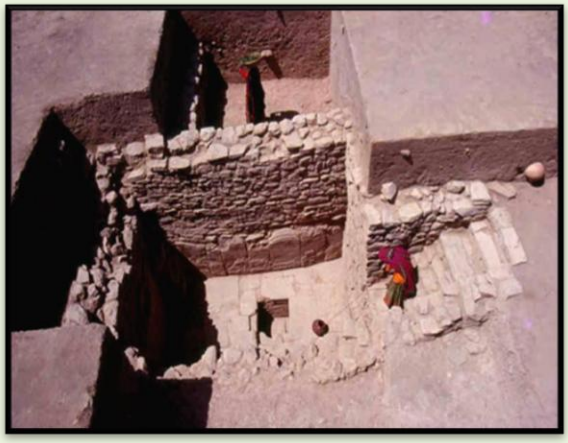

(Fig.11 Dholavira water Tanks, courtesy: R.S.Bisht)

3. Its diameter was 8ft. The kiln fired bricks were used with the fired bricks. The sizes of the brick were 11×5.5×2.5 ins and 9.6×5×2.5ins, which were used in the construction of this well. (Bisht 1999:30) The water of this well was approachable from lanes 2 and 3 and as well as streets 3 and 4. One another well was found in the south-east corner of the peripheral platform. Its internal diameter was 8ft. and it was exposed to a depth of 12ft. The digging was stopped when the water level was reached. The well was constructed with wedge shape bricks to maintain the circle. The bricks were laying on bed in mud mortar. Radial bricks were used for original construction, but not for subsequent repairs (Rao1973:67).

Discussion

The Indus Valley has been a very fertile land since the Holocene period, and the Indus River frequently brought floods and kept the soil fertile by silting, so the fertile soil and favorable climatic condition provided facilities for the rise of the civilization. Harappa, Mohenjodaro, Rakhigarhi, Balu, Banawali, Kalibangan, Lothal, Dholavira, etc. were the significant Harappan civilization sites. Agriculture was dependent on the monsoon, but the Harapan people created artificial irrigation systems including dams, canals, wells, and reservoirs. We can observe that they are aware of excellent water management and water usage for domestic, commercial, religious, and agricultural purposes. Many hydraulic structures, including the Great Bath at Mohenjodaro, the dock at Lothal Reservoirs at Dholavira, and wells at other locations, were built by the Harappan people. According to the Harappan civilization's water management system, there wasn't much rain in this area during that time. A moat was erected at Kunal and Banawali, while a canal was made at Lothal as examples of the canals they built for irrigation. The well's water was occasionally utilized in agriculture. The dock in Lothal was built for trade purposes. A river channel led from the dock to the water. Additionally, it demonstrates how the Harappan formed trade ties with the civilization that existed at the time. The commerce was conducted through land and water. The elements of public ceremonial were exposed at the Great Bath at Mohenjo-

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daro. The tank's dimensions were around 11.7 meters north to south and 6.9 meters east to west, with a maximum depth of 2.4 metres. From the north and south, two large steps descend into the tank. Due to properly fitting bricks that were edge-built with gypsum plaster, the tank's floor was watertight. In a similar way, the side walls were also built. Every tank had a thick layer of bitumen applied to the walls and, most likely, underneath the bottom to increase watertightness. The floor slopes to the southwest corner, where a little exit connects to a brick drain. Some tourists at Mohenjodaro referred to it as a bathing pool. During a sacred event, the Harappans bathed in the Great Bath. People may use the tank-contained water for residential purposes, but not for drinking. The Harappan people's primary sources of drinking water were the wells. Nearly 700 wells were found in Mohenjodaro by Michael Janson. We might thus conclude that the Harappans were exceptionally educated people who knew how to handle water well.

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