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SUSTAINABLE WATER RESOURCE MANAGEMENT: A HISTORICAL INQUIRY TO ADDRESS THE CONTEMPORARY WATER CRISIS

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ABSTRACT

Water is the most essential element of life on earth. It is easy to understand but difficult to manage. Water resource management is one of the greatest challenges on the 21st Century. However History suggests it is nothing new as challenge. Since the beginning of the civilisations water and water resources remained the reasons of their flourishment and demise. Scientifically earth revolves around sun but practically life on earth moves around water. Water is central to life. Therefore, since the life on earth and the beginning of history writings, the past tells us the stories on water management system. UN Secretary-General Ban Ki-moon on his message for World Water Day 2011 said "As the world charts a more sustainable future, the crucial interplay among water, food and energy is one of the most formidable challenges we face. Without water there is no dignity and no escape from poverty," According to World Water Development Report 4, March 2012 "Around 700 million people in 43 countries suffer today from water scarcity. By 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world's population could be living under water stressed conditions". The data suggest the crucial situation and raise question on our sustainable growth with an alarming note to decide future water policy by one and all, at local, state, national and international level with an efficient water management system.

Today, Technology and diffusion of technological advancement playing an important role in dealing with water crisis. However is there anything hidden in the past which is unnoticed and

can help further in understanding nature and natural phenomena? How people of the past dealt with the same problem, the 'Water Crisis' with or without technology? History suggests, the ancient civilizations survived for centuries and architect of those civilization have proved themselves as water resource manager of the time. To understand the importance of history to the present, R. G. Collingwood rightly said "History is for human self-knowledge...the only clue what man can do is what man has done. The value of history, then, is that teaches us what man has done and thus what man is". This chapter emphasizes upon two main concern of present related to sustainable development i.e. Water problem and Water management system. It will take an historic sketches to inform the readers about the water problems and water management system of the past, since Harappan Civilisation. It examines as to what extent history can help and answer in resolving water problems of present time.

I. Introduction

According to United Nations Development Programme (UNDP), water is 'the stuff of life and a basic human right'[1] water is an essential element for life on earth and hence becomes a core concern for law making bodies. From a legal perspective, the UNDP rightly emphasizes the importance of the human right dimension of water. Since the antiquities water is considered the basic element to sustain life on earth however the development of formal water law has been relatively slow and often patchy[2]. Water is the key to development and sustenance of all communities.[3] In general whenever the water laws are made, various dimensions are considered and various aspects are covered from historical facets to economic aspects, social needs to environmental considered before making laws for water and its management. These are basic human rights known to any civilized society.[4]All living creatures on earth have a right on air and water. The important aspects on which the water laws are made is access to water whether it is for drinking or other purpose (domestic and commercial) and control over water. Historically,

[1] UNDP, 'Human Development Report: Beyond scarcity: Power, poverty and the global water crisis' (New York 2006) <http://hdr.undp.org/en/content/human-development-report-2006>.
[2] Ibid
[3] Nandita Singh, 'Water management traditions in rural India - Valuing the unvalued' in H. Bhargava and D. Kumar (ed), *Rural Transformation* (Icfai University Press 2006).
[4] Mohit Singhvi, 'Water Management - Law and Policy in India, Environmental Protection Act, 1986' (08-Jun-13) <http://www.legalserviceindia.com/article/l420-Water-Management.html>.

one of the central concerns of water law has been the development of principles concerning access to and control over water.[5]

The parental Bodies and Act which secures the right to live, guarantee in any civilized society the right to food, water, decent environment, education, medical care and shelter.[6] Indian Constitution, Article 21 guarantees to all persons a fundamental right to life. The Indian judiciary has also played vital role for the environmental protection through its dynamic interpretation of Articles 21, 48A and 51 A (g) of the Indian Constitution**.** The Supreme Court while dealing with Article 21 of the Constitution has held that *the need for a decent and civilized life includes the right to food, water and a decent environment.*[7]In terms of statutory development, irrigation laws constitute historically the most developed part of water law.[8] Statutory water law also includes a number of pre- and post-independence enactments in various areas. These include laws on embankments, drinking water supply, irrigation, floods, water conservation, river water pollution, rehabilitation of evacuees and displaced persons, fisheries and ferries.[9]

The existing water regulatory authority and laws suffer from a number of shortcomings. In order to address them as well as to introduce new features, a Draft Model Bill for State Water Regulatory System, Model Bill has been prepared by the sub Group on Modern Bill of State Water Regulatory Authorities. The Bill is constituted by the planning commission under its Working Group on Water Governance for the Twelfth Five year Plan period (2012-2017). The object of the Draft Model Bill is 'to Reform and Replace existing Governance Structure'. The Bill also discusses about the institutions at state level and their function. Mr. Sujith Koonan and Lovleen Bhullar in their IELRC Policy Paper, while discussing about such institutions inform that the State Government is responsible for establishing the State Water Resource Regulatory and Development Council (SC) and the State Independent Water Expert Authority (SIWEA).

[5]Mohit Singhvi, 'Water Management - Law and Policy in India, Environmental Protection Act, 1986' (08-Jun-13) <http://www.legalserviceindia.com/article/l420-Water-Management.html>.

[6]Mohit Singhvi, 'Water Management - Law and Policy in India, Environmental Protection Act, 1986' (08-Jun-13) <http://www.legalserviceindia.com/article/l420-Water-Management.html>.

[7] Mohit Singhvi, 'Water Management - Law And Policy In India, Environmental Protection Act, 1986' (08-Jun-13) <http://www.legalserviceindia.com/article/l420-Water-Management.html>.

[8] Mohit Singhvi, 'Water Management - Law And Policy In India, Environmental Protection Act, 1986' (08-Jun-13) <http://www.legalserviceindia.com/article/l420-Water-Management.html>.

[9] Mohit Singhvi, 'Water Management - Law And Policy In India, Environmental Protection Act, 1986' (08-Jun-13) <http://www.legalserviceindia.com/article/l420-Water-Management.html>.

They are laying much emphasis on involvement of water users in decision-making processes; strengthening of local institutions; incorporation of traditional knowledge, skills, practices, etc.[10]

The water management traditions in rural India can be seen as organized within small-scale village communities. These traditions embody a blend of knowledge and action as a means to fulfil the water-related needs of the members through management of the resource and the sources through which it is harnessed. The elements of the system may be classified as falling within two basic realms, namely, the 'ideational' construct and the 'operational' aspects.[11]

II. Government bodies looking after water affairs at Centre and at State

A. Central Government

The Ministry of Water Resources, is the parent body working at the centre is responsible for laying down policy guidelines and programmes for the development and regulation of country's water resources.

The Ministry has been allocated the following functions[12]:

- Overall planning, policy formulation, coordination and guidance in the water resources sector.
- Technical guidance, scrutiny, clearance and monitoring of the irrigation, flood control and multi-purpose projects (major/medium).
- General infrastructural, technical and research support for sectoral development.
- Providing special Central financial assistance for specific projects and assistance in obtaining external finance from World Bank and other agencies.

[10] Nandita Singh, 'Water management traditions in rural India - Valuing the unvalued' in H. Bhargava and D. Kumar (ed), *Rural Transformation* (Icfai University Press 2006).

[11] Nandita Singh, 'Water management traditions in rural India - Valuing the unvalued' in H. Bhargava and D. Kumar (ed), *Rural Transformation* (Icfai University Press 2006).

[12] Ministry of Water Resources, Government of India, 'Functions' <http://wrmin.nic.in/forms/list.aspx?lid=239>.

- Overall policy formulation, planning and guidance in respect of minor irrigation and command area development, administration and monitoring of the Centrally Sponsored Schemes and promotion of participatory irrigation management.
- Overall planning for the development of ground water resources, establishment of utilizable resources and formulation of policies of exploitation, overseeing of and support to State level activities in ground water development.
- Formulation of national water development perspective and the determination of the water balance of different basins/sub-basins for consideration of possibilities of inter-basin transfers.
- Coordination, mediation and facilitation in regard to the resolution of differences or disputes relating to inter-state rivers and in some instances, the overseeing of the implementation of inter-state projects.
- Operation of the central network for flood forecasting and warning on inter-state rivers, the provision of central assistance for some State Schemes in special cases and preparation of flood control master plans for the Ganga and the Brahmaputra.
- Talks and negotiations with neighboring countries, in regard to river waters, water resources development projects and the operation of the Indus Water Treaty.

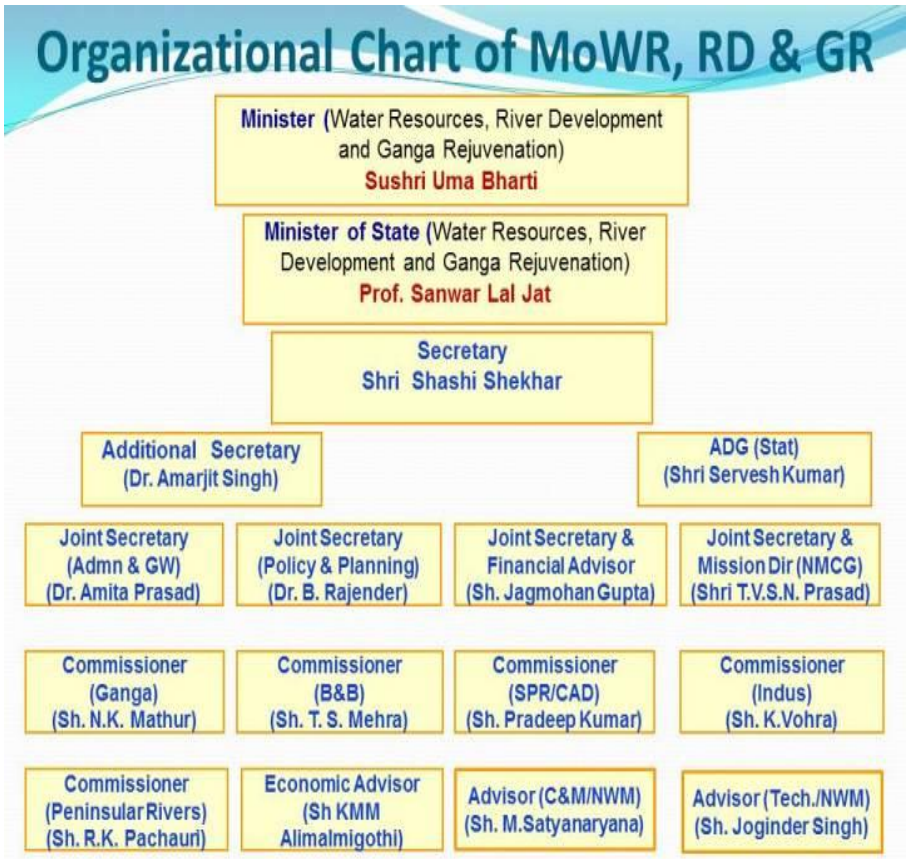

Chart 1. Organisational Chart of MoWR, RD and GR (Source: Ministry of Water Resources, River Development and Ganga Rejuvenation)

Today, India has a set structure to deal with all types of water issues. Since colonial times the Government is regulating the affairs of water in India. Tracing the historical evolution, it was during the British rule, at the beginning of the first half of the 19th century, an initiative was taken by East India Company to look after irrigation and power under the department of Public Works. However, not much impetus was given to irrigation work till the famine of 1858, when it was decided to take up canal construction work on an extensive scale and accordingly, an Inspector General of Canals was appointed.[13] Looking into the growing needs and importance of the matter in 1863 it was decided to place this subject under the charge of an irrigation expert,

[13] Ministry of Water Resources, Government of India, 'Organizational history of the Ministry of Water Resources, River Development and Ganga Rejuvenation' <http://wrmin.nic.in/forms/list.aspx?lid=277>.

with the designation of Inspector General of Irrigation.[14] The reason for dealing with water issues more seriously might be due to overall change in the policy of the British government. Inquisition into the matter suggests that major changes took place in policy during this time in form of transfer of power from East India Company to British Crown, queen's proclamation[15] which is also known as first open declaration on rights of citizens made by the Government to citizens in precolonial India.

In the first half of the 20th century, due to the growing demands of the Nationalist to establish self-government in India, the Government of India Act 1919 was passed. Under the Government of India Act 1919, irrigation became a Provincial subject and the Government of India's responsibility was confined to advice, to undertake co-ordination and settlement of disputes over right on the water of Inter-Provincial Rivers.[16] This was a landmark event in the history of water law in India. On the recommendation of the Inchcape Committee, Public Works Department was merged with the Department of Industry in 1923 and a combined department known as 'Department of Industries and Labour' looked after the subject of 'Irrigation and Power. A Central Board of Irrigation was also constituted in 1927. In 1937, the Department of Industry and Labour was bifurcated into the Department of Communication and Department of Labour. The latter was assigned the work relating to Irrigation and Power. Thereafter, on the recommendation of the Secretariat Re-organization Committee, the Department of Works, Mines and Power, was created which looked after the subject of 'Irrigation and Power'. In 1951, a new Ministry of National Resources and Scientific Research was set up and it took over the subject of 'Irrigation and Power' from the Ministry of Works, Mines and Power.

[14]Ministry of Water Resources, Government of India, 'Organizational history of the Ministry of Water Resources, River Development and Ganga Rejuvenation' <http://wrmin.nic.in/forms/list.aspx?lid=277>.

[15] The document was called "Magnacarta of the People of India" and was declared in eloquent words the principles of justice and religious toleration as the guiding policy of the queen's rule. For details please see; http://www.gktoday.in/queen-victorias-proclamation-november-1-1858. To refer more from rare collection please see http://www.csas.ed.ac.uk/mutiny/confpapers/Queen'sProclamation.pdf

[16]Ministry of Water Resources, Government of India, 'Organizational history of the Ministry of Water Resources, River Development and Ganga Rejuvenation' <http://wrmin.nic.in/forms/list.aspx?lid=277>.

A separate Ministry of Irrigation and Power was set up in 1952 to look after the subject of irrigation.[17] In January 1980, Department of Irrigation came under the new Ministry of Energy and Irrigation. On 09 June 1980, the then Ministry of Energy and Irrigation was bifurcated and the erstwhile Department of Irrigation was raised to the level of Ministry with a view to have a coordinated and comprehensive view of the entire irrigation sector.[18] In January 1985, the Ministry of Irrigation was once again combined under the Ministry of Irrigation and Power. However, in re-organization of the Ministries of the Central Government in September 1985, the then Ministry of Irrigation and Power was bifurcated and the Department of Irrigation was re-constituted as the Ministry of Water Resources.[19] In 2014 the ministry was renamed as Ministry of Water Resources, River Development and Ganga Rejuvenation.

B. Water requirement in 21st century India

Snowballing population of India has resulted in growing water demand, particularly for meeting the requirements of drinking water and food production. The present level of water utilization has been estimated to be about 690 BCM out of which about 83% is utilized for irrigation, 5% each for domestic uses and industrial uses and rest for other purposes. The "National Commission for Integrated Water Resources Development (NCIWRD)" has assessed the projected demand for water for the years 2010, 2025 and 2050. NCIWRD has made assessment both for low and high demand scenario in the year 2050. The total water requirement for meeting the demand for various uses as assessed by NCIWRD is 973 BCM for the low demand scenario and 1180 BCM for the high demand scenario. While making the assessment, NCIWRD has assumed that efficient management practices would be adopted and fully implemented and in particular, the present level of efficiency of the surface water and ground water systems would be

[17] Ministry of Water Resources, Government of India, 'Organizational history of the Ministry of Water Resources, River Development and Ganga Rejuvenation' <http://wrmin.nic.in/forms/list.aspx?lid=277>.

[18] The following items of work were transferred from the Ministry of Agriculture (Department of Agriculture & Cooperation) to the Ministry of Irrigation w.e.f. 22.07.1980:-
(i) Irrigation for agricultural purpose;
(ii) Minor and emergency irrigation; and
(iii) Ground water exploration.

[19] Ministry of Water Resources, Government of India, 'Organizational history of the Ministry of Water Resources, River Development and Ganga Rejuvenation' <http://wrmin.nic.in/forms/list.aspx?lid=277>.

enhanced to achieve the optimum level of efficiency in a phased manner.[20] The role of State in this regard becomes ineluctable to meet the growing challenge of Water issues regionally.

C. Water Regulatory Framework in Gujarat

Narmada, Water Resources, Water Supply and Kalpsar Department, Gujarat State Water Policy 2011, Water Regulatory Authority 2012 (Notification) and Model State Water Regularity Authority Act by 12th planning commission (2012 to 2017 and Draft Gujarat State Water policy 2014 are some eye catching compartments where state government utilizes the resources to deal, improve and sustain water demand of the state. To harness the valuable and limited water resources optimally, Narmada, Water Resources, Water Supply and Kalpsar Department believe that one has to resort to the internal and consolidated system such as large medium and small preservations, joint use of underground water, preservation and re-use of underground reservoir, salinity ingress, preservation and diversion of additional quota of water and utilize the same for public purpose in proper perspective.[21] To assess these, the Narmada, Water Resources and Water Supply Department of the State Government is working with an objective of harnessing the water resources optimally for the benefit of the people of the State.[22]

i. Gujarat Water Supply & Sewerage Board (GWSSB)

Gujarat Water Supply & Sewerage Board (GWSSB), is established under Gujarat Act No.18 of 1979 for rapid development and proper regulation of water supply and sewerage services in the State of Gujarat. GWSSB (The Board) has to ensure sustainable water supply and sanitation services in the State of Gujarat for accomplishing the basic health and hygiene levels leading to Socio-economic Development, Communal harmony and Peace in the society. The Department looks after rural water supply system as well as operational management of Rural Regional

[20] Ministry of Water Resources, Government of India, 'Strategic Plan for Ministry of Water Resources' (New Delhi 2011) 15 <http://www.performance.gov.in/sites/default/files/document/strategy/Water.pdf>.

[21] Narmada, Water Resources and Water Supply Department <http://guj-nwrws.gujarat.gov.in/showpage.aspx?contentid=1&lang=english> accessed 15-Aug-15.

[22] Narmada, Water Resources and Water Supply Department <http://guj-nwrws.gujarat.gov.in/showpage.aspx?contentid=1&lang=english> accessed 15-Aug-15.

Water supply Schemes covering group of villages. In this context the main function of the board is to prepare, execute, promote and finance the schemes for supply of water for drinking purposes. The rural water supply system works at grass root level to ensure water supply by installing hand pumps, mini water supply system, etc. for individual villages and small habitations they provide pipe water supply system.There are total seven state initiated schemes already running under Rural Water Supply Program[23] and four centrally sponsored scheme,[24] provides ample of scope and encourage water harvesting.

The Central Ground Water Board has prepared a Manual and subsequently a Guide on Artificial Recharge to Ground Water which provide guidelines on investigation techniques for selection of sites, planning & design of artificial recharge structures, economic evaluation & monitoring of recharge facility.[25] During the Xth Plan demonstrative studies on Artificial Recharge to Ground Water and Rain Water Harvesting have been taken up during 2006-07 by CGWB in 8 districts in Andhra Pradesh, Madhya Pradesh, Karnataka and Tamil Nadu at a total cost of Rs. 5.95 Crores . The construction of 189 artificial recharge structure out of 200 have been completed and remaining are under construction. The impact assessment studies of the completed recharge projects are being conducted by CGWB.[26]

III. Traditional Water Harvesting System in India

Since ancient times several indigenous ways have been devised to catch and store rain and river water for future use. These ways are popularly known as traditional water harvesting systems. Their technology and engineering of water harvesting differed from the present and upon the type of requirement, whether they want to save water for drinking or for irrigation. They knew both the art of rain water as well as river water harvesting.

[23]Individual water supply scheme, Regional water supply schemes, Electric / Solar energy based Mini piped water supply schemes, Rural water supply schemes for Tribal Areas,Rural water supply schemes for Scheduled Caste population,Water supply Schemes based on Sardar Sarovar Canal and Water supply Schemes with people's participation.
[24]National Rural Drinking Water Programme (NRDWP)-Normal,Desert Development Programme (DDP),Quality monitoring and Surveillance (WQMS) and Water Conservation and Prevention of Wastage of Water. For details please see https://gwssb.gujarat.gov.in/rural-water-supply-programme
[25]ARTIFICIAL RECHARGE AND RAINWATER HARVESTING STUDIES, http://wrmin.nic.in/forms/list.aspx?lid=306 accessed 15-Apr-16
[26]Ibid

It is known that all the world's oldest civilizations were based on river beds and rivers were the obvious location of civilizations, and different civilizations utilized them in different ways.[27] The practice of Rain water harvesting in India goes back to Harappan times. Since the beginning of the Civilization people knew to catch the underground water, wells had been dug in the cities of the Indus – Sarasvati Valley by the third millennium B.C., while the "Great Bath" was probably a water storage tank. The Indus Valley cities had excellent systems of water harvesting and drainage.[28]

A. ***A list describing the type of rain water harvesting down the ages is mentioned below[29]***

3rd millennium B.C.	Dams built of stone rubble were found in Baluchistan and Kutch
3000 – 1500 B.C.	Indus - Sarasvati Civilization had several reservoirs to collect rainwater runoff. Each house had an individual well
321 – 291 B.C.	Archeological evidence for dams, lakes and irrigation systems in the time of Chandragupta Maurya's rule
3rd Century B.C.	Kautilya's Arthasastra mentions irrigation using water harvesting systems
1st Century B.C.	Sringaverapura near Allahabad had a sophisticated water harvesting system using the floodwaters of the Ganges
2nd Century A.D.	Grand Anicut or Kallanai built by Karikala Chola across the river Cauvery to divert water for irrigation is still functional
11th Century A.D.	King Bhoja of Bhopal built the largest artificial lake (65,000 acres) in India fed by streams and springs

[27]CPREEC, 'TRADITIONAL WATER HARVESTING SYSTEMS OF INDIA' (10-Mar-15) <http://www.cpreec.org/pubbook-traditional.htm> accessed 20-Jul-15

[28] Ibid

[29]CPREEC, 'TRADITIONAL WATER HARVESTING SYSTEMS OF INDIA' (10-Mar-15) <http://www.cpreec.org/pubbook-traditional.htm> accessed 20-Jul-15

12th Century A.D.	Rajatarangini by Kalhana describes a well- maintained irrigation system in Kashmir

Table 1: List of rainwater harvesting system from History(Source: Ministry of Water Resources, River Development and Ganga Rejuvenation)

According to archaeological evidences of history, the knowledge of hydro-engineering was deep rooted in historic past of India. The bygones applied their knowledge in designing and constructing step wells, dams and various water structures much before Greek, Roman or other ancient civilizations.[30] When Egypt was engaged in making pyramids, India was advancing in drainage system and hydro- engineering. Since antiquity, every region of India had its own water harvesting techniques, reflecting the geographical peculiarities and cultural uniqueness of different communities.[31]

B. Traditional Water Harvesting System in Gujarat

There are 15 different types of identified Eco Zones in India in which 45 different types of traditional water harvesting systems are found. They largely comprise of different type of *Tanks,*[32] *Bhanadaras*[33] *Phad*[34] etc. Out of 15 types, 4 types of traditional water harvesting systems are found in Gujarat. Tank, Stepwells and Shallow wells and *Kunds* comes in these categories. Stepwells popularly known as *Vav/Vavdi*are found in many historic sites of Gujarat. These *Vavs* are also found in Rajasthan however popularly known as *Baoli* or *Bavadi*. Built by the nobility usually for strategic and/or philanthropical reasons, they were secular structures from

30

31Manisha Sharma Shahida Khan and Aarti Shah, 'Traditional Methods Of Water Harvesting And Applicability' (Mar-10) <http://www.esamskriti.com/essay-chapters/Traditional-Methods-of-Water-Harvesting-and-applicability-2.aspx> accessed 17-Aug-15.

32These are a small group of cultivators, built some 43,381 water tanks in the district of Bhandara, Maharashtra, around 250-300 years ago. These tanks constituted the main way of irrigation in the area until the government took them over in the 1950s. It is still crucial for sugar and rice irrigation. The tanks were of all sizes, often with provisions to bring water literally to the doorstep of villagers

33These are check dams or diversion weirs built across rivers. A traditional system found in Maharashtra, their presence raises the water level of the rivers so that it begins to flow into channels. Most Bandharas are defunct today. A very few are still in use. For details please see, Rain Water Harve4sting ,http://www.rainwaterharvesting.org/Rural/Traditional2.htm

34The community-managed phad irrigation system, prevalent in northwestern Maharashtra, probably came into existence some 300-400 years ago

which everyone could draw water.[35] Most of them are defunct today. The details of the same will be discussed later. Shallow wells called *Virdas* were dug in low depressions called *Jheels* (tanks).

C. Banni Region: Gujarat

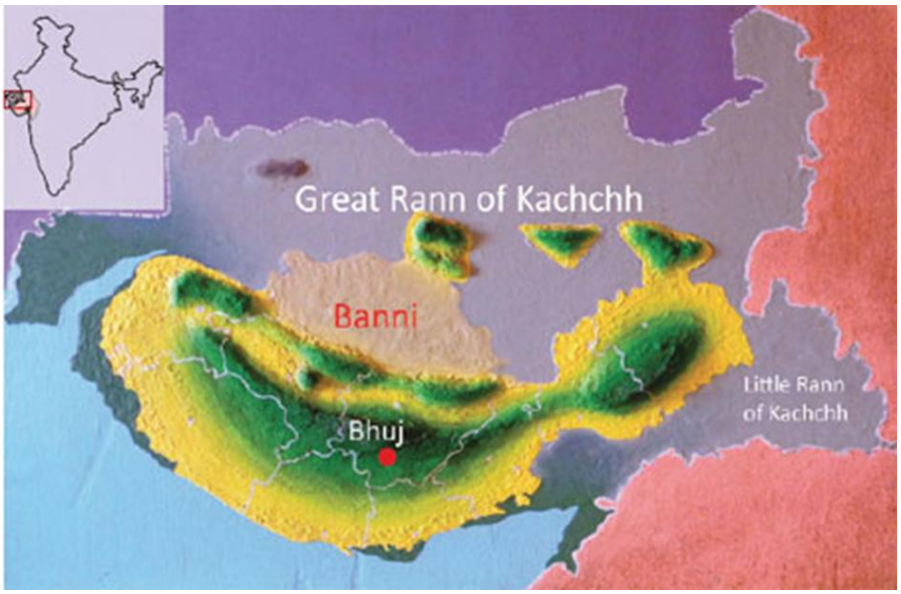

Figure 1: Banni region of Guarat

There are two main techniques of rain water harvestings found in Gujarat. One is traditional while the other is modern. First is for storage of rainwater on surface for future use and other is to recharge ground water. The storage of rain water on surface is a traditional technique and structure used were underground tanks, ponds, check dams, weirs etc. Recharge of ground water is a new concept of rain water harvesting and the structures generally used are Pits. Recharge pits are constructed for recharging the shallow aquifer. These are constructed 1 to 2 m, wide and up to 3 m. deep which are back filled with boulders, gravels, and coarse sand. The details of the traditional water harvesting structure of Gujarat are explained below:

[35]'Water Harvesting Systems: Traditional Systems' (11-May-13) <http://www.rainwaterharvesting.org/Rural/thar-desert_tradi.htm>.

Kund and Kundis

A *kund* or *kundi* looks like an upturned cup nestling in a saucer.[36] In Thar Desert of Rajasthan and some areas of Gujarat, these structures are used for rain water harvesting and collecting water for drinking. *Kunds* have a circular underground well having a saucer-shaped catchment area that gently slopes towards the center where this *kund* is situated. A wire mesh across water-inlets prevents debris from falling into the well-pit. The sides of the well-pit are covered with (disinfectant) lime and ash.[37] Usually it has dome shaped cover to protect the water. If required, water can be drawn by the use of bucket.They can be owned by only those who have money to invest and land to construct it.[38] Therefore in the interest of the poor, large public *kunds* suggested to be built by the government and other agencies inform of public work.

Figure 2: **Kunds/Kundis**[39]

[36] 'Water Harvesting Systems: Traditional Systems' (11-May-13) <http://www.rainwaterharvesting.org/Rural/thar-desert_tradi.htm>.
[37] 'Water Harvesting Systems: Traditional Systems' (11-May-13) <http://www.rainwaterharvesting.org/Rural/thar-desert_tradi.htm>.
[38] 'Water Harvesting Systems: Traditional Systems' (11-May-13) <http://www.rainwaterharvesting.org/Rural/thar-desert_tradi.htm>.
[39]Courtesy picture; www.rainwaterharvesting.org/Rural/thar-desert_tradi.htm

E. Jhalaras

Jhalaras are rectangular tanks having at three or four sides of entrance. They are found in Rajasthan and Gujarat. Traditionally they are used for religious ceremonies. These water structures were not used for drinking but for bathing and religious rites. Jodhpur City has eight Jhalaras, two of which are inside the town &six are found outside the city. The oldest Jhalaras is the Mahamandir Jhalara which dates back to 1600 AD.[40]

Figure 3: Jhalaras[41]

F. Vav / Vavadi

From the fifth to the nineteenth centuries, the people of western India built stone cisterns to collect the water of the monsoon rains and keep it accessible for the remaining dry months of the year. These magnificent structures-known as stepwells or stepped ponds-are much more than

[40] 'Water Harvesting Systems: Traditional Systems' (11-May-13) <http://www.rainwaterharvesting.org/Rural/thar-desert_tradi.htm>.

[41] Courtesy picture; www.rainwaterharvesting.org/Rural/thar-desert_tradi.htm

utilitarian reservoirs. Their lattice-like walls, carved columns, decorated towers, and intricate sculpture make them exceptional architecture.Their very presence tells much about the region's ecology and history. Stepwells have been an integral part of western Indian communities as sites for drinking, washing, and bathing, as well as for colourful festivals and sacred rituals. Steps to water trace the fascinating history of stepwells, from their Hindu origins, to their zenith during Muslim rule, and eventual decline under British occupation. It also reflects on their current use, preservation, and place in Indian communities. In stunning colour and quad tone photographs and drawings, Steps to Water reveals the depth of the stepwells' beauty and their intricate details, and serves as a lens on these fascinating cultural and architectural monuments.[42]The stepwells of Gujarat consist of a vertical shaft in the middle from which water is drawn. This shaft is surrounded by corridors, chambers and steps which provide access to the well. They were profusely carved and served as a cool resting place in summer.[43]Mata Bhavani's *Vav* at Ahmedabad, built in the eleventh century, is one of the earliest stepwells, while the *Rani ki Vav* (Queen's well) at Patan, built during the late eleventh century, is the grandest. The *Dada Harir's Vav* at Ahmedabad, and the octagonal *Vav* at Adalaj, is some of the finest examples of stepwells.[44]

Stepwell locations often suggested the way in which they would be used. When a stepwell was located within or at the edge of a village, it was mainly used for utilitarian purposes and as a cool place for social gatherings. When stepwells were located outside the village, on trade routes, they were often frequented as resting places. Many important stepwells are located on the major military and trade routes from Patan in the north to the sea coast of Saurashtra. When stepwells were used exclusively for irrigation, a channel was constructed at the rim to receive the lifted water and lead it to a trough or pond, from where it ran through a drainage system and was channelled into the fields.

A major reason for the breakdown of this traditional system is the pressure of centralization and agricultural intensification.[45]

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[42] Morna Livingston, Steps to Water: The Ancient Stepwells of India,Princeton Architectural Press, 01-Jan-2002 - Architecture - 211 pages

[43]CPREEC, 'TRADITIONAL WATER HARVESTING SYSTEMS OF INDIA' (10-Mar-15) <http://www.cpreec.org/pubbook-traditional.htm>.

[44]CPREEC, 'TRADITIONAL WATER HARVESTING SYSTEMS OF INDIA' (10-Mar-15) <http://www.cpreec.org/pubbook-traditional.htm>.

[45] Ibid

Figure 4: Vav/Vavadi; Rani Ki Vav[46]

G. Virdas

Virdas are shallow wells dug in low depressions called *Jheels* (tanks). They are found all over the Banni grasslands[47], a part of the Great Rann of Kutch in Gujarat. Over the centuries, the nomadic Maldharis have developed a rainwater harvesting technique called the "well-in-tank" system.[48] Banni is a very flat area but by studying the movement of water during the monsoons, the people learned to locate water accumulating zones.[49] Maldharis are now settled as an important community of Kutchh, and they persevere water using V*irdas*. These arera in water harvesting structures in which *Jheels* (tanks) are built in these depression areas. At the bottom of each *Jheel* are small shallow hand-dug wells called "V*irdas*".[50] By studying the flow of water during the monsoon, the Maldharis identify these depressions and make their V*irdas* there. Essentially, the structures use a technology that helps the Maldhar is separate potable freshwater

[46]Courtesy picture; http://m.inmagine.com/image-ptg01971291-Queens-step-well%20Patan%20Gujarat%20India.html

[47] According toRamble ; The Banni grassland of Gujarat is the largest natural grassland in the Indian subcontinent, and an area that is both socio-culturally unique and ecologically valuable. The Banni has a long history of migratory pastoralism going back at least 500 years, and linking with a broader geographical landscape that included Sindh in Pakistan and even extended into parts of Baluchistan and Afghanistan. This physical link was truncated at the time of partition, with pastoral communities settling on either side of the India-Pakistan border. For details please see http://www.bannigrassland.org/

[48] Friends of River Narmada, 'Kutch District, Gujarat' <http://www.narmada.org/ALTERNATIVES/banni/alt-banni.html>.

[49]Friends of River Narmada, 'Kutch District, Gujarat' called "Virdas"<http://www.narmada.org/ALTERNATIVES/banni/alt-banni.html>.

[50]Ibid

from unpotable salt water. After rainwater infiltrates the soil, it gets stored at a level above the salty groundwater because of the difference in their density. A structure is built to reach down (about 1 m) to this upper layer of accumulated rainwater. Between these two layers of sweet and saline water, there exists a zone of brackish water. As freshwater is removed, the brackish water moves upwards, and accumulates towards the bottom of the *Virda*.[51]

Figure 5: Virdas[52]

IV. Dholavira

There is one more traditional water harvesting structure found in Dholavira, Gujarat which is not listed in the above mentioned list but is found equally important to fulfil water requirements of an establishment having more than 20000 people at a time. Dholavira is one among the five largest sites of the Harappan Civilisation. It was excavated by Dr. R.S. Bisht in 1993. The site is located in Bhachau taluka, district Kutch in the state of Gujarat. To reach the site, one has to cross nearly five kilometres of the runway of white salt desert. It is located in Khdir inland. There are 14 villages and the last one, at the boarder of Pakistan is Dholavira. This 47 ha quadrangular city lay between two seasonal streams, the Mansar in the north and Manhar in the south, and had three distinct zones-the Upper, Middle and Lower Towns and shows the use of a

[51] Ibid

[52]Courtesy picture; Courtesy picture; www.rainwaterharvesting.org/Rural/thar-desert_tradi.htm

specific proportion, considering the basic unit of measurement as 1 dhanus equivalent to 1.9 meters.[53] The Dholavira site was distinct from other Harappan sites in town planning.

The excavation also tells the story of the 7 stages of the civilization, from development to maturity to decay.[54] These are identified cultural stages, serially numbered from Stage I to Stage VII …spread over a time period of one and a half millennium spanning the whole of the 3rd millennium and half of the following.[55] The city was built in a semi-arid region averaging 260 mm rainfall annually. There were no perennial water sources.[56]The water conservation of Dholavira expresses the originality and ability of the people who developed a system based on rainwater harvesting to support life in a parched landscape, with scanty sweet water. Out of the VII stages, Stage III, sub-divided into two phases, i.e. IIIA and IIIB, was most creative and important especially in relation to architectural developments. It was during this stage, Reservoirs were created on the south, west and north of the built-up divisions on an ostentatious scale and design. Finally, an outer fortification in order to surround all the components was constructed.[57]

[53]Centre UWH, 'Dholavira: A Harappan City - UNESCO World Heritage Centre' <http://whc.unesco.org/en/tentativelists/5892/> accessed 15-Jul-15.

[54]Gujarat Tourism, 'Dholavira' <http://www.gujarattourism.com/destination/details/12/339> accessed 16-Jul-15.

[55]Archaeological Survey of India, 'Excavations- Dholavira' <http://asi.nic.in/asi_exca_2007_dholavira.asp> accessed 15-Jul-15.

56'The History of the Solution' (05-Jan-11) <http://www.rainwaterharvesting.org/Solution/History_tour0.htm> accessed 15-Jul-15.

[57]Archaeological Survey of India, 'Excavations- Dholavira' <http://asi.nic.in/asi_exca_2007_dholavira.asp> accessed 15-Jul-15.

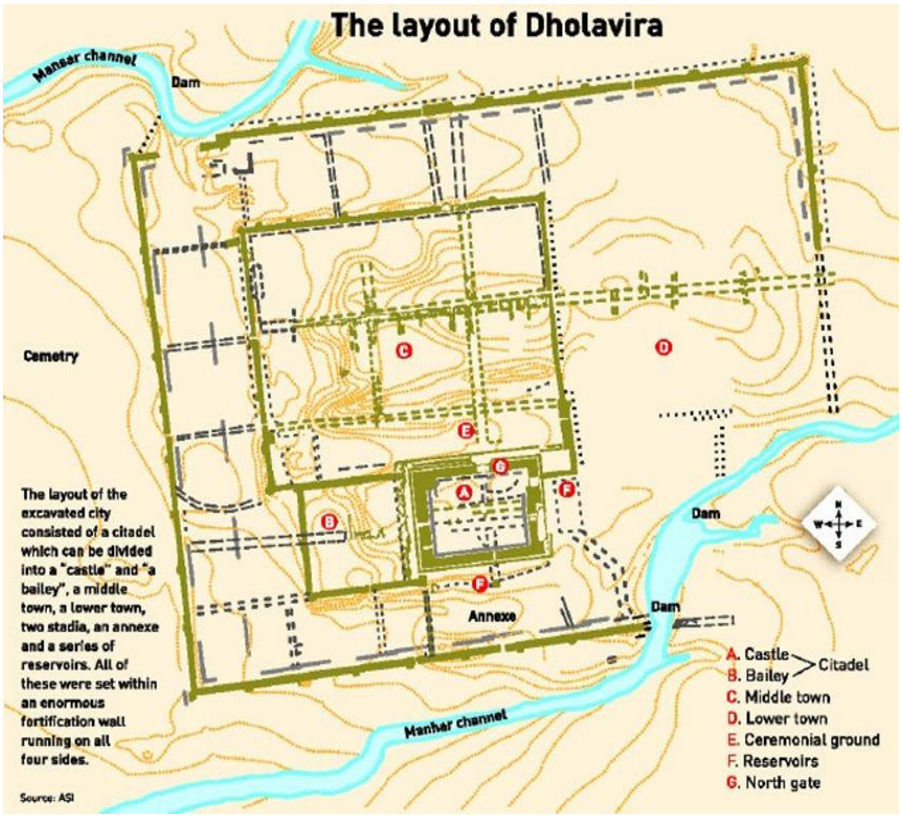

Figure 6: Dholavira Layout (Source: archaeological survey of India)

The classical Harappan culture which is extensively familiar with other Harappan settlements are from stage IV where a large number of water structures/tanks are found. According to ASI, during this stage almost all the salient features of the city planning were scrupulously maintained along with the monumental structures such as gateways, fortification, and drainage system.[58] Further ASI informs the famous ten-signed inscription of unusually large size was surely in use during this stage. All the standard Harappan elements such as pottery, seals, weights, beads, items of gold, silver, copper, ivory, shell, faience, steatite, clay and stones are found in abundance.[59]

[58]Archaeological Survey of India, 'Excavations- Dholavira' <http://asi.nic.in/asi_exca_2007_dholavira.asp> accessed 15-Jul-15.

[59]Archaeological Survey of India, 'Excavations- Dholavira' <http://asi.nic.in/asi_exca_2007_dholavira.asp> accessed 15-Jul-15.

A. The Water Harvesting System of Dholavira

The evidence from Allahdino, another site of Harappan civilization, suggests the people of the civilisation knew irrigation. According to Fairservis an expert dealing with Harappan decline describes 'Harappans as master hydraulic engineers'. He suggests, well water irrigation could be possible.[60] The presumption of Fairservis was correct in the excavation of Dholavira. Dholavira expresses unique characteristics of Water engineering, at, times almost impossible to think that as a possibly 5000 years back. Water management system of Dholavira designed to store every drop of water available shows the ingenuity of the people to survive against the rapid geo-climatic transformations.[61] Water was diverted from seasonal streams, scanty precipitation and available ground was sourced, stored, in large stone-cut reservoirs which are extended along the eastern and southern fortification.[62] To further access water, few rock-cut wells, which date as one of the oldest examples, are evident in different parts of the city, the most impressive one being located in the citadel. Such elaborate water conservation methods of Dholavira is unique and measured as one of the most efficient systems of the ancient world.[63] The ASI findings suggest that Dholavira excelled spectacularly pertaining to water harvesting with the aid of dams, drain, reservoirs and storm water management which eloquently speak of tremendous engineering skill of the builders. Equally important is the fact that all those features were integrated part of city planning and were surely the beauty aids too.[64] A brief estimate by ASI indicates that the water structures and relevant and related activities account for 10 hectares of area, in other words 10% of the total area that the city appropriated within its outer fortification. The 13 m of gradient, between high and low areas, from east to west, within the walls was ideally suited for creating cascading reservoirs which were separated from each other by

[60]Jagat Pati Joshi, 'Harappan Architecture and Civil Engineering' (16-Apr-02) <http://www.infinityfoundation.com/mandala/t_pr/t_pr_joshi_architect_frameset.htm> accessed 18-Aug-15.
[61]Centre UWH, 'Dholavira: A Harappan City - UNESCO World Heritage Centre' <http://whc.unesco.org/en/tentativelists/5892/> accessed 15-Jul-15.
[62]Centre UWH, 'Dholavira: A Harappan City - UNESCO World Heritage Centre' <http://whc.unesco.org/en/tentativelists/5892/> accessed 15-Jul-15.
[63]Centre UWH, 'Dholavira: A Harappan City - UNESCO World Heritage Centre' <http://whc.unesco.org/en/tentativelists/5892/> accessed 15-Jul-15.
[64]Archaeological Survey of India, 'Excavations- Dholavira' <http://asi.nic.in/asi_exca_2007_dholavira.asp> accessed 15-Jul-15.

enormous and broad bunds and yet connected through feeding drains.[65] The structures were huge carefully designed and utility oriented. Perhaps there must be a team of engineers to achieve such excellence in the structure and series of structures.

Six of the water tanks, one to east of castle and five of the series to the south of it, have been fully or considerably explored while a few others or other related features are testified in check digs.[66] It was found to be the largest, grandest and best-furnished reservoir of rectangular shape measuring 73.40 m N-S and 29.30 m E-W (ratio 5:2) at the top while above that there should have been a 1 to 1.20 m high embankment as evidenced at the four corners.[67]Till three levels its floor was excavated by ASI and the deepest (10.60 m) has been discovered so far. At three corners, the north-western, north-eastern and south-western, it was provided with a flight of 30 steps each while at the fourth, there should be a waste-weir that still remains to be determined by more excavation.[68] While the embankment served as a broad walkway on two sides, it was found to be a part of a wide causeway connecting it to the entrance appurtenances of the castle and, on the west, it should be flush with a 20 to 22 m promenade that lay between the castle wall and the reservoir. Inside the water structure there was found a rock cut well with a few rock cut steps and a stone-made enclosure of a later date. It is well-nigh presumable that some kind of tank was there right from Stage I.[69] Probably the tanks surrounded the settlement from three sides hence one thing is certain that it was accessible to all the city-dwellers whether living in citadel, middle town or lower town or even outsiders. Besides, it was, perhaps, used by all on some social or religious occasions.[70]To answer how such giant structures were created ASI answers that it was created by partly excavation through the alluvium and partly by cutting the underlying rock and also that it was fed with the water from the Manhar largely. The picture given bellow describes where they must have made the catchment areas for collecting water from

[65]Archaeological Survey of India, 'Excavations- Dholavira' <http://asi.nic.in/asi_exca_2007_dholavira.asp> accessed 15-Jul-15.

[66] Method ASI use at the time of exploration.

[67]Archaeological Survey of India, 'Excavations- Dholavira' <http://asi.nic.in/asi_exca_2007_dholavira.asp> accessed 15-Jul-15.

[68]Archaeological Survey of India, 'Excavations- Dholavira' <http://asi.nic.in/asi_exca_2007_dholavira.asp> accessed 15-Jul-15.

[69]Archaeological Survey of India, 'Excavations- Dholavira' <http://asi.nic.in/asi_exca_2007_dholavira.asp> accessed 15-Jul-15.

[70] This generalization is must be drawn due to the nature of Indian tradition where water is considered to be most essential for performing sacred ceremonies.

river and filled their tanks. It also gives an idea how about the citadel was surrounded by the three side large water structure fulfilling all the requisite of water for the people.

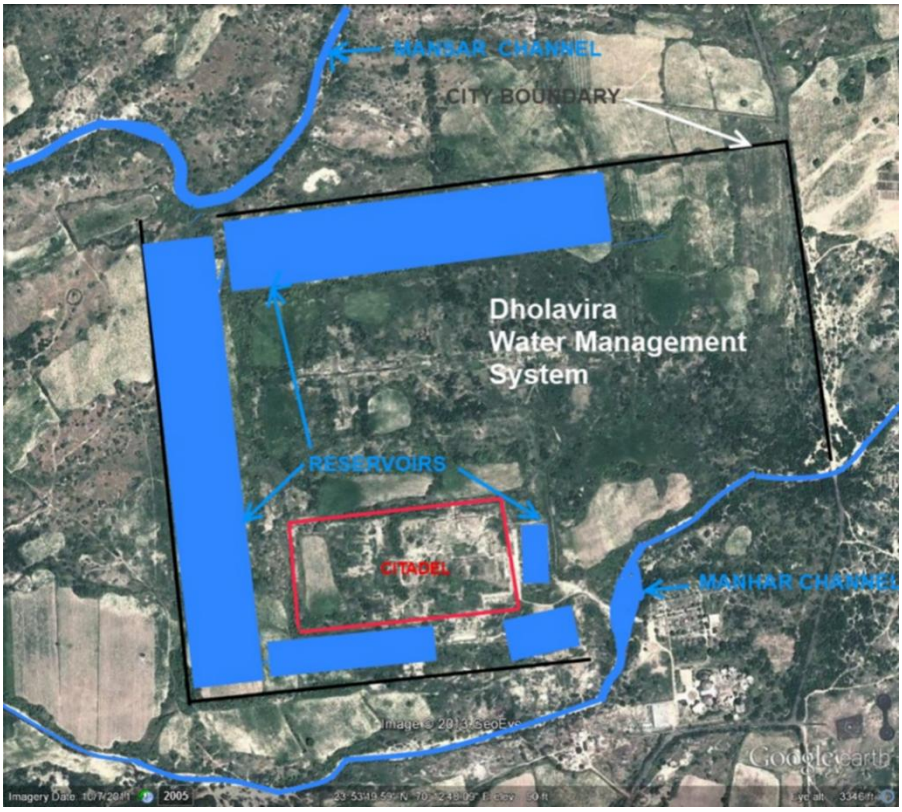

Figure 7: Dholavira Watermanagement system(Source: archaeological survey of India)

Another five tanks/ reservoirs made a series outside along the south of the citadel which have been excavated fully or partly by ASI.[71] The reservoirs are varying in size and depth and were cut into soft sedimentary sandy limestone and thus come up as two mega-units with a somewhat surprising disposition. The first two from the east form one unit and the rest the second centrally located tank exhibit genuinely a rock cut architecture of excellence both in beauty and skill and also surely in importance and use.[72] The reservoir consists of both inlying and outlying features and has a deep basin characterized with an obliquely oriented deeper trough inside. It also has a surrounding freeboard and two masonry flight of steps with an inlet

[71]Archaeological Survey of India, 'Excavations- Dholavira' <http://asi.nic.in/asi_exca_2007_dholavira.asp> accessed 15-Jul-15.

[72]Archaeological Survey of India, 'Excavations- Dholavira' <http://asi.nic.in/asi_exca_2007_dholavira.asp> accessed 15-Jul-15.

and another rock cut outlet channel, besides the outside features like a wide terrace on the west, a massive levee on the east and a stairway ascending the covered south gate of the castle. Running parallel to the defensive walls of the castle as well as the city, is a rectangular tank measuring 33.4 E-W and 8.90 to 9.45 m N-S while the upper tanks lies at the depth of 5.90 m to 6.50 m and the lower one at 7.90 m below the ancient working level. In fact, the deeper level pertains to the trough that was cut in the eastern half of the general basin. It measures 15.50 m long E-W and 5.65 m across with its vertical sides being 140, oblique to those of the main basin. The neatness with what the tank was cut is remarkable.[73] The weaker veins of the rock were scooped out and plugged with superb masonry work. The remaining two rock cut tanks lay further west. All the tanks were interconnected with drain conducting water into each other. The surplus water finally flowed out through a masonry drain into another series of reservoirs excavated further west.[74]This method helped them to store the water in abundance and face the water scarcity throughout the year.

The citadel[75] has yielded a convoluted network of rainstorm water drains. The network was furnished with slopes, steps, cascades, manholes (air ducts / water relief ducts), paved flooring and capstones. The main drains were high enough for a tall man to walk through easily. The rainwater collected through these drains was stored in yet another reservoir that was carved out in the western half of the bailey.[76] This water was probably used for drinking and was able to accomplish drinking water requirements of Citadel area along with wells which is also found inside the Citadel.

V. Conclusions

Dholavira could be a unique case where traditional and modern water harvesting techniques go hand in hand. The traditional model expresses the advancement of human achievements in technology to meet the natural challenges. The present trends of copying or following the West to solve our basic problem is at times, unsuccessful to resolve our issues of water at the grass

73Archaeological Survey of India, 'Excavations- Dholavira' <http://asi.nic.in/asi_exca_2007_dholavira.asp> accessed 15-Jul-15.

74Archaeological Survey of India, 'Excavations- Dholavira' <http://asi.nic.in/asi_exca_2007_dholavira.asp> accessed 15-Jul-15.

75 It is an outstanding feature of the Happan's Town planning and usually found on higher geographical platforms.

76 Ibid

root level. One of the foremost things which we need to understand is India is India and not Japan nor America in term of geography, meteorological conditions, density of population and the traditional value system of Indians at the grass root level does not permit to absorb overall westernization of the system. Here in no way the author means that we should not adopt the modern or advanced technologies taking place in the water harvesting system but to synthesize the modern technique with the traditional knowledge needs to be emphasized. Such synthesis may also help in achieving sustainability in our own utility oriented cultural heritage model of water management and will set an example for future generations in India. By adopting the traditional model of Dholavira and advancing and improving it with the present technology will itself be an outstanding example of sustainable development in the water management policy of the state in rural areas.

There are many benefits of adopting the Dholavira model of water harvesting. Historically, it is evident that it was a successful hydro engineering feat to meet the demand of large inhabitation. For centuries this model was capable in accomplishing the water needs of people. Comparing with big dam projects it is much more cost effective. Dam projects are also efficient but to meet the water demand of one and all ancillaries are needed with the other water harvesting systems, including the traditional one. Rajasthan and Maharashtra have set examples by utilizing their traditional water harvesting system hence increasing the probability of the success of this model. The other benefit of Dholavira model that it is, easy to be grasped by local people due to its simple engineering techniques. If the question is of funding, to get grants for such programme is not so difficult. It can be availed through Finance Committees of Panchayat System, Water and Sewerage Board Gujarat or even UNDP provide handsome grants for utilizing the traditional water harvesting systems. There are ample examples where UNDP has come forward to sustain traditional water harvesting. However the question is who will take the initiative to bring the model into reality is needs to be answered.

At present the paper has merely presented a thought for future possibility to utilize one excellent but ignored water harvesting model of India. The author's research is in progress to come with more statistical justifications to establish the efficiency of the Dholavira Model and to identify various agencies who can take suo moto action in implementing the model.

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