Relevance of Traditional Water Management Techniques: A Geographical Inquiry

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Abstract

The flourish of life on the earth became possible with the help of water. Life and livelihood of organisms completely depend on water. Though the earth is a blue planet and three-fourth surface area is covered with water, but less than one per cent of total water on the earth is usable to the living species. Human can use less than half of the fresh water on the earth surface. Surface water and ground water are the only source of water in human civilization. Over time, as population increased, demand of water has been amplified ever though water circulation through hydrological cycle remains constant. So, in ancient civilization, different techniques have been developed to fulfill requirements of life and livelihood. The indigenous techniques were developed on the basis of physico-cultural environment of the civilization. The techniques were eco-friendly, sustainable, manageable and adapted to the particular physical constraints. Modern techno-centric civilization has developed macro-scale management techniques for multipurpose use of water. But, they could not manage surface water properly. As a result, adverse impact has been found out in different riverine environment. With the increase of population, per capita water consumption has been declined. Depletion of ground water is an inevitable fact due to over withdrawal of water. Large scale water management strategies (dams) are not always free form short comings. In this situation, traditional techniques of water management are relevant and can be practiced in micro level with respect to the physical and cultural environment of the region.

Key words: Blue Planet, Physical Constraints, Riverine Environment and Traditional Techniques of Water Management

Introduction

Water is the basic element to flourish life in the planet earth. It is the elixir of life- its significance to human existence and growth has made it a subject of profound analysis in both the natural and social science (Hooja et al., 2007). For humans, it is not simply a biological necessity; the human civilizations grew around water (Gopal, 2007). It is the basic element for biological activities of plant and animal. Water plays a key role in sculpting the earth surface, moderating climate, removing and diluting water soluble wastes and pollutants (Miller, 2008). Human culture and all human endeavors depend on water. To sustain human life, basic water requirement (BWR)

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is inevitable for all human beings. Considering only drinking water and sanitation needs of an individual, BWR is 25 liters per day. Adding in water for bathing and cooking, it raises the total BWR to 50 liters per person per day (Gleick, 1988). The world's land and water resource are finite and under pressure from a growing population (FAO, 2011; Jackson et al., 2001). Availability of fresh water is limited on earth surface (0.01% of total water) and ground water (0.005%) is not a flow resource. The total amount of water on earth (liquid and frozen) is about 1400 million cubic kilometers of which 97 per cent is in salty ocean which covers about three-forth of the earth surface. Paradoxically, fresh water available for human use is less than one per cent of the total water on earth (Hooja, 2007). Approximately, volume of fresh water is 35 million km^3. Moreover, only 12500 km^3 of the fresh water is considered to be renewable and actually available for human use (Hunt, 2004). Differences in average annual precipitation divide the world's countries and people into water *haves* and *have nots (*Miller, 2008). Two reasons are mainly responsible for water crisis i.e. dry climate and excess demand. 'We currently use more than half of the world's reliable run off surface water and could be using 70-90 per cent by 2025' (Miller, 2008). 'During the 20th century, the world population has been increased three-fold but water withdrawals have increased by about six fold' (Kulkarni, 2007). Population growth is a major factor in water scarcity, mounting demand and competition for water for domestic, industrial and municipal uses (Mogelgaard, 2011). The withdrawal rate of ground water exceeds its replenishment which leads to the depletion of the resources (Hunt, 2004; IWMI, 2001). With the increase of world's population, the demand of water has increased rapidly (Mogelgaard, 2011). Similarly, urban centers are expanding more. In 2030, 60 per cent of world's population will serve by urban centers. To supply the fresh and healthy water, ground water resource may unable serve the huge demand. World receive 40000 km^3 of water as precipitation per year (Hunt, 2004). Two-third of the world's annual run off is lost by seasonal floods and it is not available for direct use (Miller, 2008). The remaining one–third, called reliable run off, is considerable as stable source of fresh water. Ancient wisdoms and techniques have been applied to provide water during dry season in different purposes of human life. Kautilya or Chanakya (371-283 B.C.) has mentioned that the state should not depend on rainfall alone for cultivation. Surface and ground water can be used for irrigation for higher productivity. So, with the application of traditional knowledge, water stress can be minimized to provide sufficient water for different aspects of human life.

Relevance of Traditional Water Management Techniques

During the past two centuries or after industrial revolution, human activities have greatly diversified causing increasingly greater demands on water. The overdraft of global groundwater is estimated to be about $200 \times 10^9 m^3$ or nearly twice the average recharge rate (International Water Management Institute, 2001) Simultaneously, the exponential increase in human population, coupled with urbanization, has increased the water requirements manifolds (Gopal, 2007). During last century, the human population tripled, global water withdrawal increase sevenfold (Miller, 2008; Ray, 2011). Global consumption of water is doubling every 20 years, more than twice the rate of population growth (Miller, 2008). According to the United Nations, more than one billion people on Earth already are in lack access to fresh drinking water. If current trend persist, the demand for fresh water is expected to rise by 56 percent more than its current availability by 2025 (Barlow, 1999). 'One of every six people does not have regular access to an adequate and affordable supply of clean water. This number could increase to at least one of every four people by 2050 (Miller, 2008). Current projection indicates that world pollution will increase from 6.9 billion people today to 9.1 billion in 2050 and food production will increase by 70 per cent in the world by three billion tones in 2050 and by 100 per cent in the developing countries (FAO, 2006; FAO, 2011).

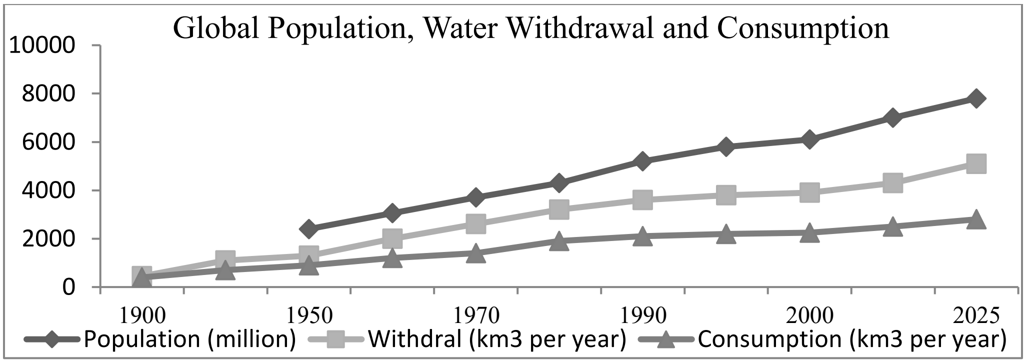


Fig. No. 1: Increase of Withdrawal and Consumption of Water with Global Population (after Shiklomanov, 1998)

Availability of fresh water is limited for the use of human. Though three-forth of the earth, the blue planet is covered by water, only 12,500 km^3 is available for human use. The distributions of water in different spheres are as follows.

Table No. 1: Distribution of Water on the Earth Surface (Source: Donkers, 2000)

Water location	% of the total amount of water
Oceans and seas	97.5
Polar ice caps and glaciers	2.05
Deep groundwater (750–5000 m)	0. 38
Shallow groundwater (less than 750 m)	0.30
Soil moisture	0.005
Lakes	0.01
Water in the atmosphere	0.001
Rivers	0.0001
Water in plants and animals, including people	0.00004

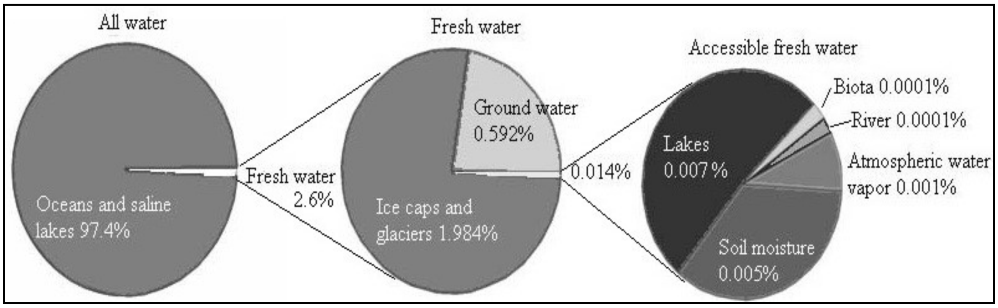
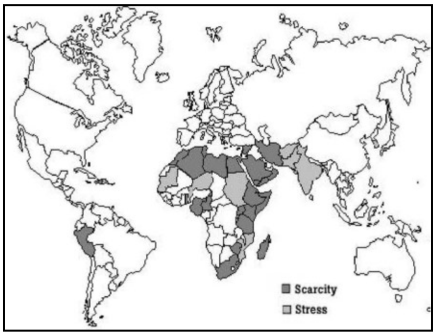


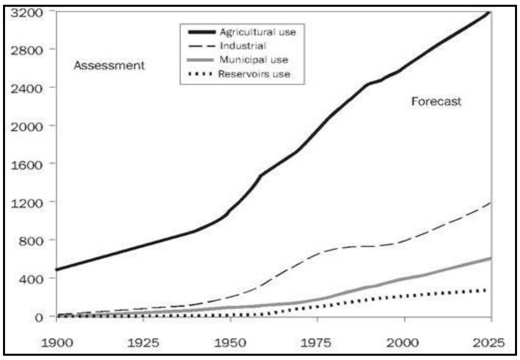
Fig. No. 2: Natural Capital: the Planet's Water Budget (after Miller, 2008)

So, 0.68 per cent ground water and 0.001 per cent of river water is available to human. This fresh water is highly variable, spatially and temporally, both in amounts and quality (Gopal, 2007). The desert climatic regions of tropic are more susceptible to water stress and scarcity.



Map No. 1: Scarcity and Stress of Water in the World (after Samson and Charrier, 1997)

Agriculture and industry are the important consumers of fresh water. The international Commission on Irrigation and Drainage (ICID, 2000) estimated that current food production would have to be doubled within the next 20 years for which there is a need for global increase of withdrawals of 15-20 per cent from surface and ground for providing irrigation to large areas (Kulkarni, 2007). Again, FAO (2002) projects that agricultural water withdrawals will increase by some 14 per cent from 2000 to 2030 to meet future food production need. So, to ensure the water supply in agricultural field, water management especially traditional wisdom and techniques can be applied to meet the future water requirement. Agriculture accounts for approximately 70 per cent of global water use and for as much as 95 per cent of water use in predominantly agriculture-based countries (UN Water and FAO, 2007). Agriculture already uses 11 per cent of the world's land surface for crop production and 70 per cent of all water withdrawn from aquifer, stream and lakes (FAO, 2011).



India has 2.45 per cent of world's land, 4.9 per cent of fresh water resource and 17 per cent of population. Annual rainfall in India is 1170 mm and average annual precipitation over India is 400 million hectare meters (m.ham) or 4000 cubic km; but almost 50 per cent water is lost to evaporation, percolation, sub-surface flows to ocean and only 1953 billion cubic meter (bcm) is account for and 1086 bcm is utilizable (Oza, 2007). It is envisaged that 70 m.ham of surface water and 35 m.ham of ground water, total 105 m.ham can be mobilized for human use by the year 2025 (Kapoor, 2007). Out of cultivable areas of India, 40 per cent are irrigated which produces 55 per cent of food and 60 per cent rain-fed areas produce 45 per cent of food (CWE, 2003). Out of irrigated areas, 31 per cent, 58 per cent and 11 per cent is irrigated through canal, ground water and tank respectively. An availability of 1700 cubic meters of water per capita annual water resource (AWR) is safe. AWR was 2214 cum in 1996 but is estimated to go down to 1496 cum by 2025 (Oza, 2007). Water stressed and Water scarce countries have fewer than 1,700 and 1000 cubic meters per year of water available per person respectively (Bernstein, 2001).Irrigation is a basic component of agriculture. But 70 per cent of world's water and 90 per cent of water in agriculture based countries is used for agriculture. In India, canal, tanks and tube wells are dominant irrigation sources which irrigate 80 per cent of crop land. After the independence in India, 40 per cent irrigated was irrigated by canal. After green revolution (1960s) in India, tube wells emerged as a source of irrigation and became most important after 1995-96. After 1960s, shearing of canal irrigated area has been decreased due to lack of construction of new canal. But, shearing of irrigated land by tube wells has been boosted up rapidly. After 1995-96, average irrigated land by tube wells is around 40 per cent whereas average canal irrigation is 27 per cent. The boom in ground-water use fuelled by tube well technology, cheap energy and profitable markets has led to widespread depletion of groundwater reserves, including irreversible mining of some aquifers (Shah, 2009; Llamas and Custodio, 2003; Morris et al., 2003). Widespread and largely unregulated groundwater withdrawals by agriculture have depleted world's most accessible and high-quality aquifers (FAO, 2011) like Punjab, North China Plain and the Souss basin in Morocco, where annual 2 meter declination have been recorded since 1980 (Garduno & Foster, 2011).

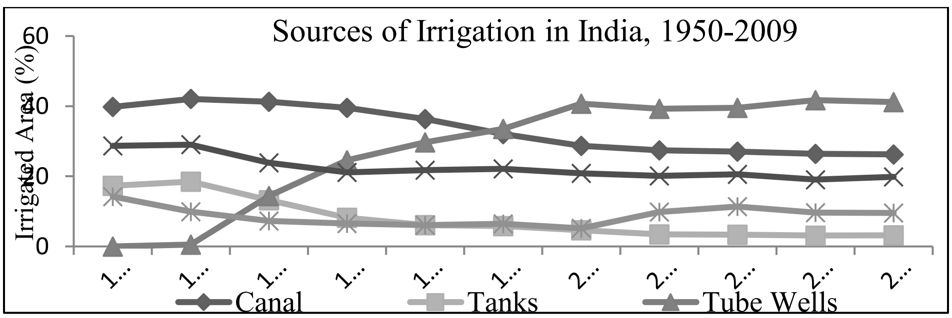


Fig. No. 4: Sources of Irrigation in India (Source:Gandhi and Namboodiri, 2002; Ministry of Agriculture, 2010)

Table No. 2: Internal Renewable Water Resources of the Mainland Sub-continental Countries and China: 2000 and 2050 (Source: Ray, 2011)

Country	Per capita consumption m^{-3} $year^{-1}$, 2000	Per capita consumption m^{-3} $year^{-1}$, 2050	Percentage decline per person, 2000–2050
Afghanistan	2527	761	70
Bangladesh	764	396	48
Bhutan	45561	17059	63
India	1249	802	36
Nepal	8601	3781	56
Pakistan	1756	721	59
China	2194	1924	12

Throughout much of the developing countries of the world, the freshwater supply comes in the form of seasonal rains. For example, India receives 90 percent of its rainfall during the summer monsoon season between June and September. Some developing countries can make use of no more than 20 percent of their potentially available freshwater resources because the water comes in torrents of rain and flooded rivers that are difficult to exploit (Hinrichson, 1997).

At present, domestic urban water required is fulfilled through mainly groundwater and river water. But the water wastage is also a great problem in Indian urban centers. The pattern of rainfall in world has changed and amount of rainfall has significantly changed the availability of fresh water and also ground water. In the present water crisis, the traditional water management techniques can be applied to reduce stress on ground water for domestic use and agricultural purposes. Early civilization has attempted differential techniques of water harvesting for optimize supply of water in agricultural land. As rain water is the source of water, the techniques were developed to protect crops from both flood and drought and to use rain water in post monsoon period. Some traditional water management techniques of the world are mentioned below.

Traditional Water Management Techniques in World

i). *Foggaras* (3000 years ago) is practiced in south-west Asia in hot desert to use ground water by underground tunnel from ground water reservoirs to palm field.

ii). *Ghouts* system is available in Algerian hot desert to plant palm trees by excavating of sands within one meter of ground water.

iii). *Khetras* (11^{th} century) are the subterranean aqueducts in Haouz plain of Marrakesh, Morroco in semi-arid Mediterranean Climate to collect ground water through canal for irrigation. The rate of water discharge is about 10 liters/seconds which never stop its flow.

iv). *Seguias* is constructed in the semi-arid region of Morroco to irrigate agricultural land from river water of 1.5 lakh hectare by 140 km canal and 1000 km small branch.

v). *Spate* irrigation (3000 B.C.) is practiced in middle-east Asian countries in dry desert for diverting flood water in agricultural land through construction of embankment along wadi and flood water through earthen or concrete structure.

vi). Water catchment (10th century) is a technique in hot desert called hassi or bir by digging out in real artesian wells with rudimentary tools.

vii). '*Zal*' or water pocket was constructed in sub-Saharan Africa in hot desert to store rain water and for supplying surface water to villagers by the project of UNESCO.

Table No. 3: Traditional Water Management Techniques in India

Techniques Name	Practiced Region	Description
Ahar pyne	Bihar	Embanked catchment basin and channels
Apatani	Arunachal Pradesh	Terraced plots connected by inlet and outlet channels
Baiji-ka-talab (rain water harvest)	Jodhpur, Rajasthan	Huge tank for rain water harvesting
Bandhimi	Konkan Region, Maharastra	Bunds for water collection
Bhandaras (Spring water harvest)	Berhampur, Madhya Pradesh	Storage tank to collect underground spring water
Cheo-oziihi	Nagaland	Channels from rivers
Flood water diversion to agricultural land	Bihar	Inundation channels for floodwaters diversion to agricultural lands
Grand Anicut	Cauvery Basin	Diverting of river water in field
Guhls and Kuhls	Western Himalaya	Spring and rain water harvesting
Haveli (Rain water for crops)	Narmada Valley, Madhya Pradesh	Water harvesting and runoff farming
Jampoi	Jalpaiguri, West Bengal	Harvesting small irrigated channels
Khazan	Maharashtra	Use of rain water for irrigation in agricultural land
Khed	Ratnagiri, Konkan Coast	Underground water tunnel from perennial stream
Khtris	Mandi District, Himachal Pradesh	Rocky pits at foot hill to collect rain water for drinking and domestic purposes
Kuchcha (well)	Uttar Pradesh	Tank irrigation

Kundi	Rajasthan and Gujarat	Rain water harvesting technique
Kund/ Sor (tank)	Jodhpur, Rajasthan	Underground storage tank
Phad	Deccan plateau, Maharastra	Check dams and canals for irrigation
Ramtek Model	Deccan Plateau, Ramtek, Maharashtra	Intricate network of groundwater and surface water bodies, connected through surface and underground canals
Roof water harvest	Kangra and Hamirpur	Rain water harvesting for irrigation, drinking and domestic purposes
Small pond for spring water collection	Temperate wet Himalaya	Use of spring water for irrigation and drinking purposes
Surangam	Kasargad, Malabar, Kerala	Bore wells, dug wells, and medium-sized surface tanks
Tanks	Arid and semiarid region	Rain fed storage structures
Tanks	Tamilnadu	Collection of run off for pisciculture, recharge of ground water, drinking water and irrigation
Virdas	Madhari tribesmen, Gujarat	Shallow wells dug in low depressions and collect enough rain water
Zabo	Arunachal Pradesh	Impounding run off
Zing	Trans- Himalayan Region, Ladakh, Jammu & Kashmir	Tanks for collecting water from melted ice, bamboo, pipe irrigation

Feasibility of Traditional Water Management at Present

Water management has been practiced from the earliest era of civilization. Kautaliya (371-283 B.C.) has mentioned in *Artha Shastra* that the basic duties of king are to construct tank, dam in river, community reservoirs. He also mentioned the punishment for breaching of tank or water distribution. According to *Rig Veda*, the life is grown with *Indra*, the god of rain. Again, collection of rain and storm water is not a new idea. Almost 4000 years ago, rain water harvesting has been practiced in the world's driest part of Jordan in the time of war to provide water to soldiers. In the driest areas of the world, rain water can be utilized as domestic and agricultural purposes. Alternatively, rain water can be used for ground water recharge in urban centers where maximum ground water exploitation is occurred. The demands of fresh water in urban centers have been increased rapidly. The urban population in developing countries is projected to double from roughly 1.9 billion in 2001 to just under 4 billion by 2030. World-wide, about three-quarters of all current population growth is in urban areas (Hunt, 2004). So, to meet the future demand in cities, water harvesting may be ensured the fresh and healthy water supply because by the year 2025, nearly two billion people will live in regions or countries with absolute water scarcity – defined as the lack of sufficient water to maintain current per capita levels of food production and meet expanding urban demands for water even at a high level of irrigation efficiency (Seckler, 1999). Traditional techniques in water management will be feasible in present context, if the hidden beauty and functionality of these age old systems are scientifically explored as well as disseminated the same to the present generation of cultivator what unfortunately is hijacked by the greedy commercial as well as lackadaisical ecological attitudes of modern agro-ecosystem. The selections of seed, quantity as well as quality of manure are to be compatible with the low water based irrigation system to gain maximum production.

i). Rain Water Harvesting

Capture of rain water mainly in the desert or semi-desert region is an age old practice. Rainwater harvesting has been practiced in Middle East Asia, ancient Rome and Mexico. In India, simple stone-rubble structures have been used for capturing rainwater date back to 3000 BC. A civilization as early as 2000 B.C. survived in the Negev Desert of what is now Israel by storing hillside runoff in cisterns (Levario, 2007). The aim of rain water harvesting is to collect rain water for future use. Mostly

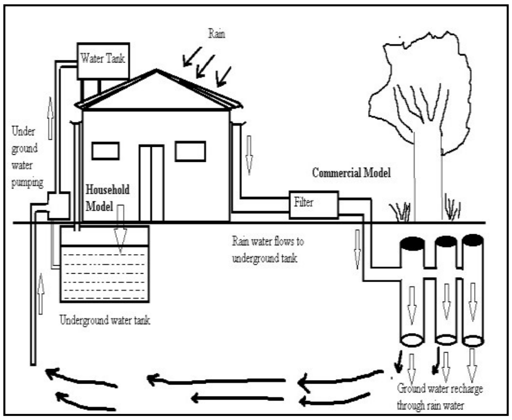


Fig. No.5: Rain Water Harvest in Household and Commercial Level

rain water is drained as runoff and little much recharge to ground water through infiltration and percolation. The scenarios in cities are different to be run off of rain water through concretization. With the construction of building, an underground storage tank can be constructed to collect rain water which provides sufficient water for domestic use. According to calculation of Heather Kinkada-Levario (2007) in his book 'Design for Water Rainwater Harvesting, Strom water catchment and Alternate Water Reuse', 36000 gallons or 136260 liters water can be produced in 1000 ft^2 of concrete roof in 60 inch or 152.4 cm rain fed areas. This amount is sufficient for basic water requirement of 7 persons for more than one year.

ii).Zabo System

The meaning of *Zabo* is impounding of water in local language (Sharma, 2013). *Zabo* system is interrelated with forestry, agriculture, livestock, and fisheries along with water and soil conservation. This method of water conservation is practiced by Chakhesang tribe in Nagaland. In hilly slope, rain water is stored in different tanks and after de-siltation, water of main pond is used for fisheries and livestock. After

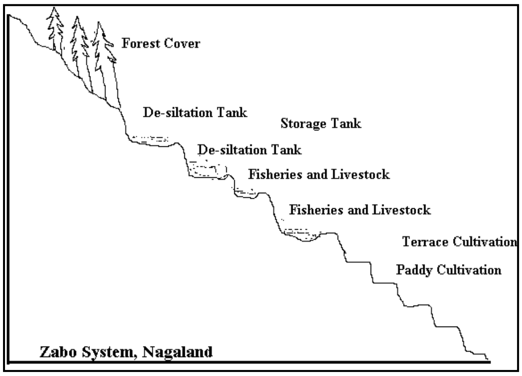


Fig. No. 5: Zabo System, Nagaland

the use of water for animal and fisheries, water is used for rice field located in down slope of the main pond. The system is a combination of forest and environment protection, water and soil conservation, nutrient management and paddy cum fish culture. This type of environment friendly and water conservation system can be practiced in hilly areas of other part of the country.

iii). Phad System of Khandesh - Maharashtra

It is a system of diversion of river water to agricultural land with the help of natural flow of water. The command area is divided into 3 to 4 parts, is called as Phad. The each Phad is irrigated by over flow of water from river directly within fixed duration. After completion of irrigation in 1st Phad, water is converted to 2nd Phad and so on. And at last excess water is returned to river again. This system is practiced in Maharastra, rain shed area of Western Ghats and water flow is diverted to agricultural land using altitudinal factors of water flow.

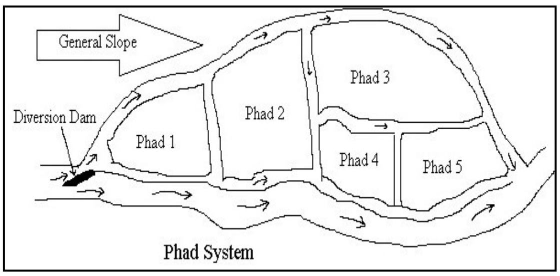
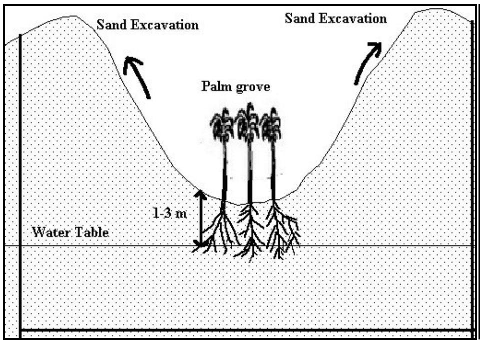


Fig. No. 8: Phad System in Maharashtra, India

iv). Ghouts and Foggaras

The *Ghout* technique is a process of "dry culture" that does not require irrigation (Mebrouk, 2014). Palm trees are directly planted above aquifer at 1-3 meter from water table. The process is well known in El Oued at Tunisia. The buried palm groves are scattered in groups of 20 to 100 palm trees in the center of large concentric basins dug by man, reaching 10 meters of difference in level, in such a way that the artificial topographic elevation, has brought to one meter or less above the ground water table (Mebrouk, 2014).



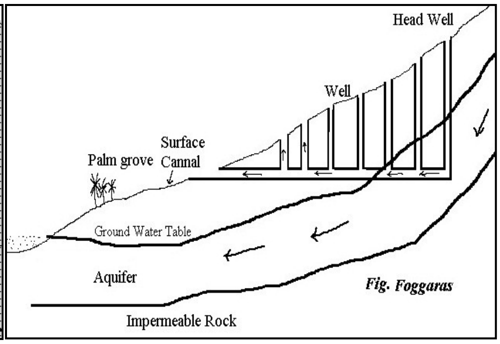


Fig. No. 6: *Ghouts* Cultivation, Middle East Asia Fig. No. : 7: Foggaras in Desert

In the dry desertic climate, ground water is used for agricultural activity through tunnel. In this system, a head wall is digging out up to ground water table and supporting walls are constructed for outcome of water. The main tunnel is constructed from head wall to agricultural field, palm grove. With the decreasing of ground water table, the main tunnel becomes defunct and at last it dies out. This system practiced from Pakisthan to Morocco.

Another original and remarkable process, for bringing up water to the surface, made great strides in the Algerian Sahara. This system of draining galleries is found in a geographical marea going from Pakistan to Morocco. They have different names: *Khirras* in Pakistan and in Afghanistan, *Falaj* in Arabic Emirates, *Ngoula* or *Friga* in the south of Tunisia, *Khettaras* in the south of Morocco, *Chegga* in some regions of the southeast Algeria etc.

Conclusion

From the above discussion, this can be concluded that the different indigenous water management techniques have been practiced from ancient civilization to meet their basic needs. Micro water management technique can provide water for agriculture in hilly region, rain shadow region, flood plain, water stress area and desert. The traditional techniques have been developed on the basis of indigenous knowledge with eco-friendly model. Roof-top harvesting is a practice to store water in an underground tank which can be used in domestic level after purification or to recharge ground water. This can reduce over-land flow and intensity of flood. Again, diversion of river flow can be used as irrigation in agricultural land in slightly gentle agricultural land which is called *phad*. Traditional knowledge are helpful to make reliable and sustainable use of water which not only will restrain the water stress situations in the planet Earth but may also help to maintain the pristine equilibrium among different natural systems including human ecology.

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