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# Importance of Rainwater Harvesting in India

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## Preview

India is one of the maximum water scarcity nations in the World mainly from its groundwater to all versions of aquatic ecosystems. During the past one decade, India's groundwater (e.g., Wells, Aquifer) levels decreased by 65% due to 9/10$^{th}$ of groundwater is extracted for irrigation [Bahri, 2016]. In July 2016, India commissioned approximately half of its 50 biggest dam in which around 84% of the total addition to the net irrigated area is arisen from the groundwater. The report from the Central Ground Water Board, Ministry of Water Resources reveals in India over 100 million people residing in the areas of dangerous water quality [CGWB, 2016]. Groundwater levels declining drastically because farmers, domestic effluents and industries drain wells, river water and aquifers. The available water is often severely polluted [Senthil Kumar, 2013, 2014] which threats to use even for agriculture as several vegetables and edible crops could uptake toxic contaminants and end up in humans and animals. Among the Indus Water Treaty Law Suite#632, among groundwater quality districts, only 59 are above Bureau of Indian Standards (BIS) limits namely IS-10500-1991. Whenever a particular pollutant concentration exceeds the BIS limits, drinking water is considered too unsafe. Environmental scientists and researchers expects the future may only be worse, with the national supply predicted to fall about 50% below demand by 2030 [Shiao., et al. 2015]. The statistical records also reveal that ~54% of India's total area facing high to extremely high water stress in which 600 million people are at higher risk of surface water supply disruptions. Farmers in arid areas, or areas with irregular rainfall, depend heavily on groundwater for irrigation. The Indian government subsidizes the farmer's electric pumps and places no limits on the volumes of groundwater extraction which creates a widespread pattern of excessive water use. The India Water Tool (IWT) specifically designed to help companies, government agencies, civil society organizations, and other stakeholders assess water risks. The critical first step toward reversing the damage already been initiated to India's water supplies and protecting against chronic struggles. However, IWT may only be a first step in a long process of risk reduction and mitigation, but they are a most essential one of the country's well being.

The advantages of groundwater policy in India is licensed to dig a well and extract the water without any limitation. The disadvantages are decentralized access which easily accessible is being over exploited in several states. Community driven, decentralized water management was the norm in India almost 100 years before, namely, before the development of the modern canal-based flood irrigation system and extraction technology. Nevertheless, water scarcity episodes started in India in recent years due to over population, industrialization, and failure of monsoon. For example, in Maharashtra state on 22$^{nd}$ March World Water Day followed by India's famous Holi festival, farmers sighed at the sky as they marked one of their worst droughts in almost four decades [Talwar, 2016]. Water scarcity has been showing symptoms of being a national malaise in news trickling in from across the country. The Central Water Commission (CWC) reported that

India's major dams were at just 27% of their full capacity and well short of the 10 year average, and 91 reservoirs were 30% below the previous year's levels. Due to acute shortage of water, authorities in Maharashtra's Latur district have clamped Section 144 of the Criminal Procedure (CrPC) as a preventive measure to tackle possible violence over water. Relief measures remain largely on paper or take too long to reach distressed communities. Further, faulty crop planning and skewed water utilization are depleting into the ground and surface water resources. The water situation in Delhi reflects India's urban water crisis in a microcosmic way. Rapid population growth is undermining the capital's sustainability. Per-capita availability of fresh water is down to 1118 cubic meters from 3091 cubic meters in between 1962 to 2014.

The rainwater is the only immediate abundant and clean source of water, however the distribution is neither uniform nor assured in all parts. India receives about 400 million hectare meters of rain/year over an area of 329 million hectares. The rainfall ranges from as low as 100 mm in the Thar Desert to 15,000 mm in the northeast regions. Water resources minister encouraging farmers in water scarce regions to buy treated water for irrigation recycled by industries in order to conserve fresh water. This is more an outcome of the problem than a solution in itself. Whatever the detail, there is certainly an urgent need to look at the big picture from the crop mix of warped policies that favor more elite users of water than the truly needy. India can ill afford a simple pay and use model in a nation where 2/3$^{rd}$ of the irrigation comes from truant monsoons. This just be the right occasion for some serious introspection on a range of issues, including conservation, augmentation of groundwater, and management and governance issues relating to water [Senthil Kumar, 2013, 2014]. Considering those aforementioned facts, rainwater harvesting is very urgent, important not only for India but also the countries belong in the dry tropical belt. The rainwater is collected from various hard surfaces such as rooftops and/or other man-made aboveground hard surfaces, wells, ponds and lakes. [Devkota., *et al*. 2013, 2015] developed a methodology for rainwater harvesting, and found that the building design (e.g., dimensions) and function (e.g., educational and residential) play critical roles in the environmental performance of the system. In addition, we cannot rule out rainwater harvesting in rural areas such as artificial lakes, dig and abandoned wells, increase the depth of present lakes, ponds, wells.

India has a history of rainwater harvesting around the third century BC, particularly from the farming communities of Kutch. In ancient Tamil Nadu, rainwater harvesting was done by Chola Kingdom. The rainwater from the Brahadeeswarar Temple in Thanjavur District was collected in Shivaganga tank. Chola King Karikala Cholan built the Grand Anicut named Kallanai across the Cauvery River to divert water for irrigation. The Veeraanam tank was built (1011 to 1037 CE) in Cuddalore District of Tamil Nadu state to store water for drinking and irrigation purposes. Veeraanam is a 16 km long tank with a storage capacity of 41,500,000 m$^3$. Archaeological evidence shows that the practice of water conservation is deeply rooted in the science of ancient India. Excavations show that the cities of the Indus valley civilization had excellent systems of water harvesting and drainage. The settlement of Dholavira, laid out on a slope between two storm water channels, is a great example of water engineering. Chanakya's Arthashashtra mentions irrigation using water harvesting systems. Sringaverapura, near Allahabad, had a sophisticated water harvesting system that used the natural slope of the land to store the flood waters of the river Ganga (CPREEC 2017).

**Rainwater Harvesting Methods**

Rainwater harvesting can be implemented following stages;

1) Collecting and transporting rainwater through catchment areas and conduits. Particularly, the catchment of a rainwater harvesting system is the surface which receives rainfall directly. It can be a paved area like the terrace, courtyard of a building, gutters and downspouts. Conduits are the pipelines that carry rainwater from the catchment, rooftop to the harvesting system, 2) Filtration; a filter unit is a chamber installed with filtering (e.g., physical, chemical and biological) media to remove debris and dirt (i.e., physical filtration) from water before it enters the storage tank or recharge structure, 3) Storage in tanks for reuse or recharging the groundwater levels; the harvested water can now be stored in storage tanks for immediate usage, which are designed according to the water requirements. Existing non-potable water storage tanks in the society can also be used to store the harvested rainwater. The collected rainwater can also be used to recharge the groundwater levels by using structures like dug wells, bore-wells, tube-wells, recharge trenches and recharge pits. For rooftop rainwater harvesting through an existing tube-wells and hand pumps, filter or desilting pit should be provided so that the wells are not silted. Such tube-wells if pumped intermittently, increase the efficiency of recharge. If the ground water reservoir is recharged through, shaft, dug well, inverted filter may be provided.

Storage tanks are the expensive components of rainwater harvesting system. Storage tank prices vary based on variables such as size, material and complexity. There are numerous types of storage tanks available in the market. Storage can be done in aboveground or belowground and storage containers can be made from galvanized steel, wood, rain barrels, concrete, clay, plastic, fiberglass, polyethylene, masonry and several other mediums. The classic examples of aboveground storage include cisterns, barrels, tanks, garbage cans, above ground swimming pools. In order to suppress the growth of algae, storage tanks should be opaque and preferably placed away from direct sunlight. The tanks should also be placed close to the area of use and supply line to reduce the distance over which the water is delivered. In addition, consider placing the storage in an elevated area to take advantage of gravity flow. The tank should always be placed on a stable and level area to prevent it from leaning and possibly collapsing. A storage tank must be located on a lower level than the roof to ensure that it filled completely. Rainwater delivering systems should be gravity fed or pumped to the landscape or end user areas. The filtering system needed for potable systems to make the water safe for human consumption. Particularly water should be passed through physical (i.e., soil, sand, dirt and debris), chemical (i.e., chlorine) and biological (i.e., UV filtration to kill bacteria and pathogens) filtration in case if it is used for drinking and cooking purpose.

Rain chains are absolute alternative to conventional downspouts, especially made from copper. The rain chain guides the rain from the terrace, down the chain or through the cups and eventually end up in the garden, watering can, rain barrel and alternative rainwater storage tank. It is recommended that the storage tank should not be installed close to a source of contamination (e.g., septic tank and wastewater drainage). A rainwater system must include installation of an overflow pipe which empties into a non-flooding area. Excess of the water may also be used for recharging the aquifer through dug well, abandoned hand pump and tube-well. A speed breaker plate must be provided below the inlet pipe in the filter so as not to disturb the filtering material. Storage tanks should be accessible for cleaning so that the inlet into the storage tank should be screened and can be cleaned regularly. Water may be disinfected regularly before using for drinking purpose by chlorination, UV disinfection and boiling.

In addition to rooftop harvesting, the rain saucer, which looks like an upside down umbrella, collects rain straight from the sky. This decreases the potential for contamination and makes potable water in developing countries a potential application. Other applications of this freestanding rainwater collection approach are sustainable gardening and small plot farming. Traditionally, storm water management using detention basins served a single purpose. However, optimized real time control lets this infrastructure double as a source of rainwater harvesting without compromising the existing detention capacity. This has been used in the Environmental Protection Agency (EPA) Headquarters to evacuate stored water prior to storm events, thus reducing wet weather flow while ensuring water available for future use. This has the benefit of increasing water quality released and decreasing the volume of water released during combined sewer overflow events. Besides, check dams are constructed across the streams to enhance the percolation of surface water into the subsoil strata. The water percolation in the water impounded area of the check dams can be enhanced artificially several fold by loosening the subsoil strata and overburden using Ammonium nitrate-fuel oil (ANFO) explosives as used in open cast mining. Thus, local aquifers can be recharged quickly using the available surface water fully for use in the dry season.

**Advantages of Rainwater Harvesting**

Rainwater harvesting paves the way to use of a natural resource and reduces flooding, storm water runoff, soil erosion, landslides and contamination of surface water with pesticides, sediment, metals and fertilizers. Rainwater provides an excellent source of water for landscape irrigation, with no chemicals such as fluoride, chlorine, and no dissolved salts and minerals from the soil. Home harvest systems can be relatively simple to install and operate, may reduce the water bill and carbon footprint by using in the home garden, car wash, and even to indoor usage with the proper filtration system. It also promotes both water and energy conservation and sustainability and without a filtration system for landscape irrigation. Collecting rain helps the environment by reducing the amount of water that has to be extracted from the earth or processed in water treatment facilities. The approximate average rainwater collection from the house with a 2,000 square foot terrace can be approximately 50,000 gallons/year, which depending on the location and average rainfall/year. Rainwater harvesting provides an independent water supply during regional water restrictions, and in developed countries, is often used to supplement the main supply. It provides water when a drought occurs, can help mitigate flooding of low lying areas, and reduces demand on wells which may enable groundwater levels to be sustained. It also helps in the availability of potable water, as rainwater is substantially free of salinity and other salts. Application of rainwater harvesting in urban water system provides a substantial benefit for both water supply and wastewater subsystems by reducing the need for clean water in water distribution system, less generated storm water into the sewer system, and a reduction in storm water runoff polluting freshwater bodies. In saline or coastal areas, rain water provides good quality water and when recharged to ground water, it reduces salinity and also helps in maintaining balance between the fresh saline water interfaces. In the islands, due to the limited extent of fresh water aquifers, rainwater harvesting is the most preferred source of water for domestic use. In the desert, where rainfall is low, rainwater harvesting has been providing relief to people. Capturing and storing rainwater for use is particularly important in dry land, hills, urban and coastal areas. In alluvial areas energy saving for 1-meter rise in ground water level is around 0.40 kilowatt per hour.

**Rejuvenate Indian Waters**

Ponds, lakes, rivers, and wells provide humans with services that include water for irrigation, drinking, and industrial use, dilution of pollutants, hydroelectric power, transportation, recreation, fish, and aesthetic feature. The recent generation understand the importance of contributing towards a resilient ecosystem, though our waterways restoration mechanism. It is highly possible that our valuable resources will be restored and flourished in order to bring the change because the urban lakes are facing the severe degradation due to increased industrialization and disturbed lake ecology such as morphology, water quality and aquatic organisms. Furthermore it is noteworthy to indicate that encroachment and draining of lakes, pollution from domestic sewage and industries such as nitrates, phosphates, organic contaminants, emerging environmental pollutants and other toxic waste, loss of biodiversity also resulting in loss of food like fish and impact on human health by increased jaundice, typhoid, gastroenteritis and vector transmitted diseases like malaria among the population living around lakes as well as using the water cannot be ruled out. Consequently, in order to restore our natural ecosystems, rainwater harvesting in the lakes with proper construction/design is the utmost priority. For example, cleaning and increasing depth of the disappearing wells, lakes, ponds and implement proper filtration units in the collected rainwater is necessary. Further, blocking domestic and industrial discharge directly to the lake and divert them to the sewage treatment facilities is necessary not only to manage water scarcity at present and also give the bright future to our future generations.

The holistic programme of watershed development which addresses the following main concerns; 1) percolation tanks or spreading basin, 2) contour bunding, 3) recharge through abandoned dug wells, bore wells and tube wells, 4) recharge pits, 5) gabion structure, 6) modification of village tanks as recharge structure, 7) rainwater harvesting through gully plug, 8) rainwater harvesting through recharge shaft, 9) roof top rainwater harvesting for domestic use of individual households and small communities in remote areas, 10) creating surface water storages in the form of check dams, dug ponds for irrigation and drinking water for cattle, 11) recharging ground water through check dams, percolation tanks, sub-surface dykes to augment drinking water availability in wells, tube wells, hand pumps and 12) soil moisture conservation especially in rain fed hilly areas (e.g., bench terracing, contour bunding). In addition, rainwater harvest rejuvenation in India has been classified based on states belongs to particular ecosystem. In mountainous regions like Himachal Pradesh, Jammu and Kashmir, Uttrakhand, Sikkim and North Eastern States, percolation tanks, modification of village tanks as recharge structure, gabion structure, and contour bunds are best suited. In alluvial soil areas like Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal, percolation tanks, recharge pits are advisable. In hard rock regions like Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh and Kerala, recharge through abandoned dug wells, bore wells, tube wells, modification of village tanks as recharge structure, gabion structure, and percolation tanks are suitable system.

The tribal population of Jhabua village dug up contour trenches on hillocks around the lake at regular intervals to allow rainwater to percolate and raise the water table [Ahuja 2016]. Now people living in a cluster of eight to ten settlements in villages neighboring Hathipawa hillock, where the trenches were dug over a 2 square km area, are getting water in hand pumps and tube wells around the year. The water is now available at a depth of 60 feet when compared to 300 to 400 feet earlier. Before the trenches, the terrain and the underlying geological structure led to most of the average annual rainfall of 850 mm draining away, leaving the soil dry and the groundwater availability low, showed a study by the Central Ground Water Board (CGWB) in Jhabua. These ecological safe traditional systems are viable and cost-effective alternatives to rejuvenate India's depleted water resources. Similarly, lake rejuvenation started to occur in Maharashtra state with Malguzari tanks were ponds made for water harvesting by the Malguzaars community, who were zamindars or tenants in eastern Vidarbha, Maharashtra 200 years ago. These tanks provided water for irrigation and also increased the availability of fish for local consumption until 1950. After the government takes over the lake and implement tax, more than 1000 tanks in the Vidarbha region bore the brunt of this decision and went unmaintained since then. From 1983, an independent committee ruled that the tanks, which were of great significance to modern irrigation projects, and individual from Malguzaar family decided to initiate the process of rejuvenating the tanks with the monitory help from government. The first tank that was restored in 2008 was the Janbhora Malguzari tank located 35 km away from Bhandara. The first step was to desilt the tank to remove the fine sand and earth that is carried by moving water and deposited as a sediment. After the desilting was completed, the boundary wall of the tank was strengthened. This rejuvenation work has resulted in recharging groundwater levels and has also increased agricultural output and fish production in the area [Purohit 2016].

**India's Rainwater Harvesting So Far**

There is no authenticated potential of rainwater harvesting has been assessed in India. The Tamil Nadu state was the first one to initiate rainwater harvesting compulsory for every building to avoid groundwater depletion. The scheme was launched in 2001 and has been implemented in all rural areas. It gave excellent results within five years, and slowly every state took it as a role model. Since its implementation, Chennai has had a 50% rise in water level in five years and the water quality improved significantly. In Bangalore Karnataka state, adoption of rainwater harvesting is compulsory for every house owner of a building having the site area measuring 60 feet × 40 feet and above and for newly constructed building measuring 30 feet × 40 feet and above dimensions. In this particular regard, Bangalore Water Supply and Sewerage Board has initiated and constructed a rainwater harvesting theme park in ~5,000 $m^2$ of land. In this park, 26 different types of rainwater harvesting models are demonstrated along with the water conservation tips. In Kerala state, a community driven project to recharge wells in Thrissur District, Kerala State, has made life easier for thousands of banana and coconut farmers after Mazhapolima project initiated. The project involved setting up a system to harvest and channel rainwater to recharge open well. Besides, rooftop rainwater harvesting systems involving a pipe and gutter are being used to recharge home open wells, under a Mazhapolima, which has increased the utilizable groundwater potential in a sample 7.6 sq. km coastal area by 43.35 million liters as well as improved the quality of water [CPREEC, 2017].

In Rajasthan state, rainwater harvesting has traditionally been practiced by the people of the Thar Desert. Water harvesting systems are widely used in other areas of Rajasthan as well, for example, the chauka system from the Jaipur district. In this instance, the non-governmental organization constructed sand dam, which slows down the flow of water, thus increase the amount of percolates to underground. In Maharashtra state at present, rainwater harvesting is compulsory for any new housing society to be registered. In Mumbai rainwater harvesting is being considered as a good solution to solve the water crisis. The Mumbai City council is planning to make rainwater harvesting mandatory for large societies [CPREEC, 2017].

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