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Water Management: Natural Resources Conservation

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ABSTRACT: Water management is the control and movement of water resources to minimize damage to life and property and to maximize efficient beneficial use. Good water management of dams and levees reduces the risk of harm due to flooding.

KEYWORDS: water, resources, natural, management, conservation

I. INTRODUCTION

Water- a must for all life forms on earth and the most important natural resource. We all know that about three-fourths of the earth's surface is covered with water. But about 96.5% of the global water resources come from the oceans and seas. In India, the water resources amount to an estimated 1897 square kilometer per annum. However, we all know about the shortage of Water we are facing as a country.

Some quick Facts and Figures

- The total volume of water on earth's surface- 96.5%
- The total volume of usable freshwater- 2.5%
- The volume of freshwater in ice-sheets and glaciers- 70%
- Stored groundwater- 30%
- Precipitation (rainfall) in India- 4% of earth's total
- India's rank in the world for water availability per person (per annum)- 133

Conservation & Management of Water Resources

'Water water everywhere, not a drop to drink.' It is a very old saying in a different reference to the situation. But, this is exactly what we fear will happen very soon, if we do not wisely use and conserve our water resources.[1,2,3]

Research shows that by 2025, India, along with many other countries will face a serious scarcity of water. Many regions in our country are currently undergoing the process of 'water stress'. According to a research by Falken Mark, a Swedish expert on water, 'water stress' happens when the water availability falls below 1000 cubic meters per person per day.

Though blessed with large rivers like the Ganga, Yamuna, Godavari, Narmada, and others, India's socio-economic development has a lot to contribute to decreasing water resources. Rising population, industrialization, urbanization and modernization of agriculture, are some of the main reasons for water shortages in many parts of the country. As a result, most of our prominent rivers, especially the smaller ones have become toxic with waste products and pollution.

Saving our Water Resources

Water is indeed an essential resource for life on earth and it must be conserved. In fact, historically, humans had learned to conserve the available water resource by building dams.

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Dams

Dams are simply hydraulic structures that act as a barrier between the source and destination of flowing water. Earlier, these dams were small and hand-made. In our modern society, engineering techniques and methods are used to construct most of these dams.

Depending on its need, the water flow can be obstructed, redirected or slowed down using a dam. The barrier often creates a small reservoir or a lake, collecting the excess flow of water. People use most dams for irrigation. While some dams are used for generating electricity, which we know as 'hydropower' or 'hydro energy'.

Dams can be of different types and of various sizes. While timber dams are made from wood, the masonry or embankment dams are made with stones and concrete. Dams can also be low, medium or high in height, depending on their location and usage. Though dams can be helpful in conserving water resources, too many of them can also cause over sedimentation of the river beds.

Also, over usage of dams can reduce the aquatic life of the river, on which they flow. That is why we also have more natural and long-lasting methods of saving our water resources. The two most widely used methods are:

Rainwater Harvesting

You must have come across this term from multiple media sources. Rainwater harvesting is one of the most efficient and effective ways of conserving water. It is more like the recycling of natural water. In this, the rooftop rainwater harvesting is a common practice in states like Rajasthan, West Bengal, Meghalaya, and major parts of South India, where rainfall is usually heavy. People connect PVC pipes to a drain on their roof and the rainwater is collected below in large storage tanks. This water is then utilized for daily needs even after rains are over. Mostly, people do not collect the water off first rainfall but thereafter. In Shillong and other parts of Meghalaya and rain prone regions of North East, water from rooftop rainwater harvesting covers about 15-25% of household water requirements.

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DIY: You can try a home experiment for your learning exercise. Collect the rainwater and store it. You can even filter the water for a clean output. Now, use this water for your household needs or plants. Did you know? In the state of Tamil Nadu, it is compulsory for every house/residential building to have a rooftop rainwater harvesting system!

Bamboo Drip Irrigation system

This is an indigenous method which has been in practice for about 200 years in the north-eastern states of India. While this practice helps conserve the region's water resources, it also helps in irrigation of local farms and fields. People use bamboo pipes for tapping the waters of streams and springs. About 18020 litres of water flow through a network of pipes and end up as drips on the farmlands.[4,5,6]

II. DISCUSSION

Sustainable Management of Water involves using water in ways that fulfil present, environmental, social and financial requirements without risking the capacity to meet those needs for the future.

Water Conservation

- Human intervention could change the availability of water in various regions worldwide
- Generally, regions of water scarcity are nearly identified in the regions of acute poverty
- Rains in India are primarily due to the monsoons and falls in certain months of the year
- Despite nature's monsoon bounty, failure to sustain water availability has mainly resulted in:
- Loss of vegetation cover
- Diversion of water towards high demanding crops
- Pollution from industrial effluents and urban wastes
- Irrigation methods like dams, tanks and canals have been utilised in various parts of India since the past
- The maintenance of those irrigation systems was an area affair. This system changed when the British arrived
- These mega-projects eventually led to the neglect of local irrigation methods that have been in practice since our past
- Further, the government also took control over the administration of these systems leading to the loss of control over the local water sources by the local people

Dams

- Large dams can ensure adequate water storage not only for irrigation but also for generating electricity
- Canal systems leading from these dams can transfer large amounts of water over great distances
- Indira Gandhi Canal Helped information of greenery in considerable areas of Rajasthan
- However, the advantages are cornered by a couple of people as there's no equitable water distribution
- People on the brink of source grow water-intensive crops like sugarcane and rice, while people farther downstream don't get any water

Issues related to large dams

- Social problems: Dams immerse many peasants and tribes without adequate compensation or rehabilitation
- Economic problems: Dams immerse vast public money without generating proportionate benefits

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- Environmental problems: Dams contribute enormously to deforestation and loss of biological diversity

Water Harvesting
Watershed management emphasises scientific soil and conservation of water to extend biomass production. The aim is to develop primary resources of land and water, to supply secondary resources of plants and animals to be used in a manner that would not cause ecological imbalance.

- Watershed management extends the production and income generated by the watershed community
- It mitigates droughts and floods and increases the lifetime of the downstream dam and reservoirs
- Many organisations are rejuvenating ancient water harvesting systems, which can act as alternatives to the megaprojects like dams

Some indigenous water saving methods are:
1. Dug small pits and lakes
2. Simple watershed systems
3. Built small earthen dams
4. Sand and limestone reservoirs
5. Set up rooftop water-collecting units

Pollution of the River Ganga
The Ganga runs over 2500 km from Gangotri within the Himalayas to Ganga Sagar in the Bay of Bengal.
- It is being drained by more than 100 towns and urban communities in Uttar Pradesh, Bihar and West Bengal that empty their trash and excreta into it
- Largely untreated sewage is unloaded into the Ganges daily
- Industries contribute chemical effluents to the Ganga's pollution load and therefore toxicity kills fish in large sections of the river

Initiatives Taken To Clean The Ganga
- Ganga Action Plan: This multi-crore project came about in 1985 because the water quality in the Ganga deteriorated with a high presence of coliform count. Coliform is a rod-shaped bacteria found in human intestines, whose presence in water indicates contamination by disease-causing microorganisms[7,8,9]
- Namami Gange Programme: It's an Integrated Conservation Mission approved as a Flagship Programme by the Union Government in June 2014
- It was dispatched to achieve the vitally double targets of powerful reduction of contamination preservation and revival of River Ganga
- The National Mission for Clean Ganga is the implementation wing brought in October 2016

Water is an essential need for all terrestrial living forms. Water bodies are polluted as a result of human interference. Human activity also alters the availability of water in different areas. Despite adequate monsoon, the inability to maintain underground water supply has been caused mainly through loss of plant cover and contamination from untreated wastewater. Dams and canals have been utilised for irrigation in various areas for a long time. Large dams can offer enough water storage not just for agriculture but also for electricity generation. Canal systems connecting these dams may transport significant volumes of water across long distances. Sustainable management of natural resources (water) is a necessity of the present to prevent water scarcity in the future.

III. RESULTS

Water conservation aims to sustainably manage the natural resource of fresh water, protect the hydrosphere, and meet current and future human demand. Water conservation makes it possible to avoid water scarcity. It covers all the policies, strategies and activities to reach these aims. Population, household size and growth and affluence all affect how much water is used.

Climate change and other factors have increased pressure on natural water resources. This is especially the case in manufacturing and agricultural irrigation.[1] Many countries have successfully implemented policies to conserve water conservation.[2] There are several key activities to conserve water. One is beneficial reduction in water loss, use and waste of resources.[3] Another is avoiding any damage to water quality. A third is improving water management practices that reduce the use or enhance the beneficial use of water.[4][5]

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Technology solutions exist for households, commercial and agricultural applications to reduce the . Water conservation programs involved in social solutions are typically initiated at the local level, by either municipal water utilities or regional governments.

Aims

The Aims of water conservation efforts include:[10,11,12]

- With less than 1% of the worlds water being freshwater,[6] one aim is ensuring the availability of water for future generations where the withdrawal of freshwater from an ecosystem does not exceed its natural replacement rate.
- Energy conservation as water pumping, delivery, and wastewater treatment facilities consume a significant amount of energy. In some regions of the world, over 15% of the total electricity consumption is devoted to water management.
- Habitat conservation where minimizing human water usage helps to preserve freshwater habitats for local wildlife and migrating waterfowl, but also water quality.[7]

Strategies

The key activities to conserve water are as follows:

- Any beneficial reduction in water loss, use and waste of resources.[3]
- Avoiding any damage to water quality.
- Improving water management practices that reduce the use or enhance the beneficial use of water.[4][5]

One of the strategies in water conservation is rainwater harvesting.[8] Digging ponds, lakes, canals, expanding the water reservoir, and installing rain water catching ducts and filtration systems on homes are different methods of harvesting rain water. Many people in many countries keep clean containers so they can boil it and drink it, which is useful to supply water to the needy.[8] Harvested and filtered rain water can be used for toilets, home gardening, lawn irrigation, and small scale agriculture.[8]

Another strategy in water conservation is protecting groundwater resources. When precipitation occurs, some infiltrates the soil and goes underground.[9] Water in this saturation zone is called groundwater.[9] Contamination of groundwater causes the groundwater water supply to not be able to be used as a resource of fresh drinking water and the natural regeneration of contaminated groundwater can take years to replenish.[10] Some examples of potential sources of groundwater contamination include storage tanks, septic systems, uncontrolled hazardous waste, landfills, atmospheric contaminants, chemicals, and road salts.[10] Contamination of groundwater decreases the replenishment of available freshwater so taking preventative measures by protecting groundwater resources from contamination is an important aspect of water conservation.[8]

An additional strategy to water conservation is practicing sustainable methods of utilizing groundwater resources.[8] Groundwater flows due to gravity and eventually discharges into streams.[9] Excess pumping of groundwater leads to a decrease in groundwater levels and if continued it can exhaust the resource.[8] Ground and surface waters are connected and overuse of groundwater can reduce and, in extreme examples, diminish the water supply of lakes, rivers, and streams.[10] In coastal regions, over pumping groundwater can increase saltwater intrusion which results in the contamination of groundwater water supply.[10] Sustainable use of groundwater is essential in water conservation.

A fundamental component to water conservation strategy is communication and education outreach of different water programs.[11] Developing communication that educates science to land managers, policy makers, farmers, and the general public is another important strategy utilized in water conservation.[11] Communication of the science of how water systems work is an important aspect when creating a management plan to conserve that system and is often used for ensuring the right management plan to be put into action.[11]

The conservation of water is extremely important in order to preserve wildlife habitats. There are many organisms in temperate regions who are affected by shortages in water.[12] Additionally, many freshwater organisms are increasingly feeling the impacts of water pollution as it disrupts the ecosystem.[12]

"World Water Day" is celebrated on 22 March.[13]

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Social solutions

Drip irrigation system in New Mexico

Water conservation programs involved in social solutions are typically initiated at the local level, by either municipal water utilities or regional governments. Common strategies include public outreach campaigns,[14] tiered water rates (charging progressively higher prices as water use increases), or restrictions on outdoor water use such as lawn watering and car washing.[15] Cities in dry climates often require or encourage the installation of xeriscaping or natural landscaping in new homes to reduce outdoor water usage.[16] Most urban outdoor water use in California is residential,[17] illustrating a reason for outreach to households as well as businesses.

One fundamental conservation goal is universal water metering. The prevalence of residential water metering varies significantly worldwide. Recent studies have estimated that water supplies are metered in less than 30% of UK households.[18] Although individual water meters have often been considered impractical in homes with private wells or in multifamily buildings, the US Environmental Protection Agency estimates that metering alone can reduce consumption by 20 to 40 percent.[19] In addition to raising consumer awareness of their water use, metering is also an important way to identify and localize water leakage. Water metering might benefit society by providing a financial incentive to avoid waste in water use.[20]

Some researchers have suggested that water conservation efforts should be primarily directed at farmers, in light of the fact that crop irrigation accounts for 70% of the world's fresh water use.[21] The agricultural sector of most countries is important both economically and politically, and water subsidies are common. Conservation advocates have urged removal of all subsidies to force farmers to grow more water-efficient crops and adopt less wasteful irrigation techniques.[22]

New technology poses a few new options for consumers, features such as full flush and half flush when using a toilet are trying to make a difference in water consumption and waste. It is also possible to use/"pollute" the water in stages (keeping use in flush toilets for last), hereby allowing more use of the water for various tasks within a same cycle (before it needs to be purified again, which can also be done in-situ). Earthships often use such a setup.
Also available are modern shower heads that help reduce wasting water: Old shower heads are said to use 5-10 gallons per minute, while new fixtures available use 2.5 gallons per minute and offer equal water coverage.[23] Another method is to recycle the water of the shower directly, by means a semi-closed system which features a pump and filter. Such a setup (called a "water recycling shower") has also been employed at the VIRTUe LINQ house. Besides recycling water, it also reuses the heat of the water (which would otherwise be lost).[24][25]

Contrary to the popular view that the most effective way to save water is to curtail water-using behavior (e.g., by taking shorter showers),[26] experts suggest the most efficient way is replacing toilets and retrofitting washers; as demonstrated by two household end use logging studies in the US.[27][28]

Water-saving technology for the home includes:

- Low-flow shower heads sometimes called energy-efficient shower heads as they also use less energy
- Low-flush toilets, composting toilets, and incinerating toilets. Composting toilets have a dramatic impact in the developed world, as conventional Western flush toilets use large volumes of water
- Dual flush toilets include two buttons or handles to flush different levels of water. Dual flush toilets use up to 67% less water than conventional toilets

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- Faucet aerators, which break water flow into fine droplets to maintain "wetting effectiveness" while using less water. An additional benefit is that they reduce splashing while washing hands and dishes
- Raw water flushing where toilets use sea water or non-purified water (i.e. greywater)
- Wastewater reuse or recycling systems, allowing:
- Reuse of greywater for flushing toilets or watering gardens
- Recycling of wastewater through purification at a water treatment plant. See also Wastewater - Reuse[13,14,15]
- Rainwater harvesting
- High-efficiency clothes washers
- Weather-based irrigation controllers
- Garden hose nozzles that shut off the water when it is not being used, instead of letting a hose run.
- Low flow taps in wash basins
- Swimming pool covers that reduce evaporation and can warm pool water to reduce water, energy and chemical costs.
- Automatic faucet is a water conservation faucet that eliminates water waste at the faucet. It automates the use of faucets without the use of hands.

Smart water meters are also a promising technology for reducing household water usage. A study conducted in Valencia, Spain, shows the potential that smart meter-based water consumption feedback has for conserving water in households. The findings showed that households that were equipped with smart water meters increased their water savings. This technology works to show people how much water they were using in their household, suggest ways they can reduce water usage, and incentivize water savings with physical rewards.[29]

Applications

Many water-saving devices (such as low-flush toilets) that are useful in homes can also be useful for business water saving. Other water-saving technology for businesses includes:

- Waterless urinals (also can be installed in schools)
- Waterless car washes
- Infrared or foot-operated taps, which can save water by using short bursts of water for rinsing in a kitchen or bathroom
- Pressurized waterbrooms, which can be used instead of a hose to clean sidewalks
- X-ray film processor re-circulation systems
- Cooling tower conductivity controllers
- Water-saving steam sterilizers, for use in hospitals and health care facilities
- Rainwater harvesting
- Water-to-water heat exchangers.

It is important to consider implementing water-conserving changes to industrial and commercial application use. It was found that high-income countries use roughly 59% of their water for industrial usage while low-income countries use 8% for industrial usage.[30] One big change that industrial and commercial companies can implement are to improve the assessment and maintenance of water systems.[31] It is easy to add water-efficient applications but it is the proper maintenance and inspection of it which will lead to long-term changes. A water conservation plan can be created, including adding various goals and benchmarks for both the employees and the company.[31] Another change that industrial and commercial companies can make are to check water-consuming systems at regular intervals for any leaks or problems.[31] By doing this, it will ensure that water is not unnecessarily being lost and there is no excess money being spent on utility bills. A third change[16,17,18] that industrial and commercial companies can implement is installing a rain sensor. This sensor should be able to detect when precipitation is occurring and stop the program which would normally irrigate the land. After the rain ends, the sensor should turn the program back on and resume to its normal watering cycle.[32]

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Agricultural applications

Overhead irrigation, center-pivot design

Water is an essential part of irrigation. Plants always take a lot of ground water thus ground water should be replenished. For crop irrigation, optimal water efficiency means minimizing losses due to evaporation, runoff, or subsurface drainage while maximizing production.[33] An evaporation pan in combination with specific crop correction factors can be used to determine how much water is needed to satisfy plant requirements. Flood irrigation, the oldest and most common type, is often very uneven in distribution, as parts of a field may receive excess water in order to deliver sufficient quantities to other parts. Overhead irrigation, using center-pivot or lateral-moving sprinklers, has the potential for a much more equal and controlled distribution pattern. Drip irrigation is the most expensive and least-used type, but offers the ability to deliver water to plant roots with minimal losses. However, drip irrigation is increasingly affordable, especially for the home gardener and in light of rising water rates. Using drip irrigation methods can save up to 30,000 gallons of water per year when replacing irrigation systems that spray in all directions.[34] There are also cheap effective methods similar to drip irrigation such as the use of soaking hoses that can even be submerged in the growing medium to eliminate evaporation.

As changing irrigation systems can be a costly undertaking, conservation efforts often concentrate on maximizing the efficiency of the existing system. This may include chiselling compacted soils, creating furrow dikes to prevent runoff, and using soil moisture and rainfall sensors to optimize irrigation schedules.[19] Usually large gains in efficiency are possible through measurement and more effective management of the existing irrigation system. The 2011 UNEP Green Economy Report notes that "[i]mproved soil organic matter from the use of green manures, mulching, and recycling of crop residues and animal manure increases the water holding capacity of soils and their ability to absorb water during torrential rains",[35] which is a way to optimize the use of rainfall and irrigation during dry periods in the season.

As seen in China, plastic mulch also has the potential to conserve water in agricultural practices. The "mulch" is really a thin sheet of plastic that is placed over the soil. There are holes in the plastic for the plants to grow through. Some studies have shown that plastic mulch conserves water by reducing the evaporation of soil moisture, however, there haven't been enough applied studies to determine the total water savings that this practice may bring about.[36]

Water reuse

Water shortage has become an increasingly difficult problem to manage. More than 40% of the world's population live in a region where the demand for water exceeds its supply. The imbalance between supply and demand, along with persisting issues such as climate change and population growth, has made water reuse a necessary method for conserving water.[37] There are a variety of methods used in the treatment of waste water to ensure that it is safe to use for irrigation of food crops and/or drinking water.

Seawater desalination requires more energy than the desalination of fresh water. Despite this, many seawater desalination plants have been built in response to water shortages around the world. This makes it necessary to evaluate the impacts of seawater desalination and to find ways to improve desalination technology. Current research involves the use of experiments to determine the most effective and least energy intensive methods of desalination.[38][39][40]

Sand filtration is another method used to treat water. Recent studies show that sand filtration needs further improvements, but it is approaching optimization with its effectiveness at removing pathogens from water.[41][42] Sand

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filtration is very effective at removing protozoa and bacteria, but struggles with removing viruses.[43] Large-scale sand filtration facilities also require large surface areas to accommodate them.
The removal of pathogens from recycled water is of high priority because wastewater always contains pathogens capable of infecting humans. The levels of pathogenic viruses have to be reduced to a certain level in order for recycled water to not pose a threat to human populations. Further research is necessary to determine more accurate methods of assessing the level of pathogenic viruses in treated wastewater.[44]

Problem areas

Wasting of water

Leaking garden hose bib

Wasting of water is the flip side of water conservation and, in household applications, it means causing or permitting discharge of water without any practical purpose. Inefficient water use is also considered wasteful. By EPA estimate, household leaks in the US can waste approximately 900 billion gallons (3.4 billion cubic meters) of water annually nationwide.[45] Generally, water management agencies are reluctant or unwilling to give a concrete definition to a relatively vague concept of water waste.[46]

However, definition of water waste is often given in local drought emergency ordinances. One example refers to any acts or omissions, whether willful or negligent, that are "causing or permitting water to leak, discharge, flow or run to waste into any gutter, sanitary sewer, watercourse or public or private storm drain, or to any adjacent property, from any tap, hose, faucet, pipe, sprinkler, pond, pool, waterway, fountain or nozzle."[47] In this example, the city code also clarifies that "in the case of washing, "discharge," "flow" or "run to waste" means that water in excess of that necessary to wash, wet or clean the dirty or dusty object, such as an automobile, sidewalk, or parking area, flows to waste.

Water utilities (and other media sources) often provide listings of wasteful water-use practices and prohibitions of wasteful uses. Examples include utilities in San Antonio, Texas.[48] Las Vegas, Nevada,[49] California Water Service company in California,[50] and City of San Diego, California.[51] The City of Palo Alto in California enforces permanent water use restrictions on wasteful practices such as leaks, runoff, irrigating during and immediately after rainfall, and use of potable water when non-potable water is available.[52] Similar restrictions are in effect in the State of Victoria, Australia.[53] Temporary water use bans (also known as "hosepipe bans") are used in England, Scotland, Wales and Northern Ireland.[54]

Strictly speaking, water that is discharged into the sewer, or directly to the environment is not wasted or lost. It remains within the hydrologic cycle and returns to the land surface and surface water bodies as precipitation. However, in many cases, the source of the water is at a significant distance from the return point and may be in a different catchment. The separation between extraction point and return point can represent significant environmental degradation in the watercourse and riparian strip. What is "wasted" is the community's supply of water that was captured, stored, transported and treated to drinking quality standards. Efficient use of water saves the expense of water supply provision and leaves more fresh water in lakes, rivers and aquifers for other users and also for supporting ecosystems. For

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example, we should not treat toilet as a trash can. If we flush cigarette butts or tissues in it, we are wasting gallons of water. Because the process of recycling water cannot be accomplished[19]

IV. CONCLUSION

A concept that is closely related to water wasting is "water-use efficiency". Water use is considered inefficient if the same purpose of its use can be accomplished with less water. Technical efficiency derives from engineering practice where it is typically used to describe the ratio of output to input and is useful in comparing various products and processes.[56] For example, one showerhead would be considered more efficient than another if it could accomplish the same purpose (i.e., of showering) by using less water or other inputs (e.g., lower water pressure). The technical efficiency concept is not useful in making decisions of investing money (or resources) in water conservation measures unless the inputs and outputs are measured in value terms. This expression of efficiency is referred to as economic efficiency and is incorporated into the concept of water conservation.[20]

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