**Water Sustainability**

Water is our largest natural resource, but only 3% is freshwater and only one-third of it is available for agriculture and drinking purpose. The freshwater we use comes from two sources: Surface water runoff and groundwater. Precipitation that flows into water bodies such as streams, rivers, and lakes at the surface of the earth without infiltrating the surface or returning to the atmosphere by evaporation or transpiration is called surface water runoff [1]. Some of the precipitation percolates to the surface, where it collects as soil water, partially filling the pores between surface soil particles and rocks. Aquifers are underground rocks that are water-bearing layers and water in them is called groundwater. The water collects on the layer of impermeable rock or on compacted clay called unconfined aquifers. When the water is collected between two impermeable rocks is called confined aquifers [2].The ability to meet current water demands without compromising the ability of future generations is known as sustainable water management. It requires multidisciplinary and comprehensive strategies that consider technical, environmental, economic, aesthetic, social, and cultural concerns. In recent years, the term “sustainability” has come to use frequently which includes various planning activities it has a slightly different meaning depending on the user's point of view. Sustainable water management also refers to the efficient and comprehensive use of water resources. The need for sustainable, integrated, and thorough water management is growing as a result of today's diverse demands on water resources. Sustainable water management aims to organize the various aspects of water management and maximize benefits. This can be done through several processes such as water reuse, water recovery, and minimal water consumption. Long-term availability and supply of clean water for people and other living things are necessary for water sustainability. The physical, chemical, and, biological properties of natural waters that are required to fulfill long-term societal and ecological needs are known as sustainable water quality[3].The driving factors, effects, and best management practices affecting the future of our water are highlighted in this chapter.

One of the most crucial resources that determine the ability to produce food and the corresponding potential for population growth is water. The spatial distribution of measured global water resources in terms of precipitation per unit area corresponds to the population density. Climate change, water pollution, and the negative effects of water resource management practices are the three main threats to the sustainability of water resources. The most recent thinking on the environmental, social, and political aspects of sustainable management of water supplies at local, regional, or basin scales is represented by sustainable water resource management[4].

According to experts, water scarcity and water pollution are among the biggest environmental problems for mankind in the 21st century. The search for determinants of water-saving behavior is one of the main goals of environmental psychology and other environmental sciences, as human behavior is the most important cause of water problems. Such searches enable intervention programs to include important predictors of water conservation to promote sustainability[5].

To assist water management authorities, in recognizing instances of water stress, The Water Foundation and its collaborators including the Bay Institute, Environmental Science Associates, and Sonoma Ecology Centre published a set of guidelines known as the Sustainable Water Management (SWM) Profile in 2012. By analyzing management responses to these conditions and measuring soil, ocean water gauges progress toward sustainable water management. In December 2019, The Water Foundation and its partners published a paper summarizing the application of the SWM profile and the lessons learned during its development and testing through two pilot projects. In 2016, the Inland Empire Utilities Agency worked with the Water Foundation to conduct a pilot assessment of water stress vulnerability and management measures.

Globally sustainable water means that at least 20 to 50 liters of water per day needed for life is affordable and available to everyone on this planet. Following this, the United Nations General Assembly recognized that the right to safe drinking water and sanitation is an essential human right for the full enjoyment of life and all human rights. Water sustainability also means integrated and efficient management of water resources. Today there is a lot of demand for water resources, so sustainable, integrated, and comprehensive water management is needed.

UK regulator describes "sustainable water" as follows:

"A sustainable water cycle in which we can meet our water and sanitation needs while enabling future generations to meet their needs."

According to the Environmental Protection Agency (EPA) in the United States, for water utilities, this can mean effective planning for water and wastewater systems to manage operations and infrastructure. Their floors, while ensuring the sustainability of the communities they serve. The agency says, the benefits of considering sustainability when planning infrastructure include: Maximizing environmental, economic, and social benefits by targeting and selecting projects through a transparent and inclusive process with the community.

Typically, water utilities have long-term planning deadlines and long-term infrastructure operations and maintenance commitments. As a result, EPA sustainability guidelines require that drinking water and sanitation systems be “strong and comprehensive” so that water infrastructure investments are cheap, resource-efficient, and cost-effective.

Water sustainability also varies across utilities. Some utilities and local governments are incorporating sustainability considerations into their planning processes, but are looking to improve and refine their current efforts. Others may focus on how these considerations can help meet existing regulatory or service requirements cost-effectively.

These tactics ought to serve as the foundation for sustainable management of its water resources. Using wastewater as a source of water, energy, and fertilizer; prioritizing water conservation; reducing water demand; enforcing strict control over water pollution; prioritizing the use of rainwater as a source of water; and preventing flooding and waterlogging disasters[7].

**Water consumption – In agriculture**

The agricultural sector uses 70% of the world's annual water supply, so it will be one of the first to feel the effects when water demand is higher than supply. Sundstrom said, "Groundwater is already being used up in many places, where there isn't enough capacity to meet demand, production will go down, which will directly affect farmers' income and food security"[8].

Agroforestry: The best way to keep groundwater from running off and to keep the land from getting worse is to keep plants alive. But cutting down trees is often done to make more room for farms or pastures. In Colombia, the GEF is helping herders keep the tree cover high so that cattle can graze in the shade. It has made pastures more productive and also cut down on how much water is used. Wetlands need to be protected because they keep freshwater from getting dirty or drying up during dry spells. Burkina Faso's pasture land and water supplies have been hurt by too many cattle. The Least Developed Countries Fund is working on a project to improve how the Mare d'Oursi Wetlands Basin in the north of the country is managed. This will help farmers deal with the effects of climate change. It will also keep the lakes and streams in good shape, which they use to raise animals. To maintain balance in the ecosystem, food, water, and energy all depend on each other. In the last ten years, the GEF has been a leader in improving the security of water, food, and energy by using an integrated nexus approach. The nexus approach is the GEF's current four-year plan for dealing with water use and waste at the level of ecosystems in agriculture, energy, and the urban environment. There are two main places where water comes from: rivers and lakes, like the Great Lakes, and aquifers in the ground. Both sources can be used for a lot of different things, like homes, businesses, industries, farming, making energy, mining, and having fun. The Upper Midwest Water Science Centre collects basic hydrological data and does studies to find out how much water is available now, how surface water and groundwater interact and affect availability, how quickly we are using our water resources, and how much water will be available in the future[9].

Leaders of thought from inside and outside the water industry will get together in small groups called "think tanks" to look at the future of water through the lens of five key drivers. The Water 2050 ‘think tanks’ will look at these drivers and use them to guide all the work that will be done in the future.

**INDICATORS:**

One of the key problems to economic development and food production is the sustainable use of global resources. In recent years various studies have reported that there has been an increase in the usage of non-renewable water resources due to human reliance. This has affected the regional water supply and also food production due to less irrigation. Indicators are widely used in water sustainability management[10].Several parameters are used to qualitatively and quantitatively analyze different parameters to represent water sustainability. They are used to get information and estimate changes over a while and evaluate progress toward goals. Indicators must be chosen carefully and there are different categories considered before an indicator is chosen. Some of them are water supply reliability, water quality, ecosystem health, social benefits, equity, etc. Various indicators are used to estimate the usage like using the water crowding index (threshold value) which shows different levels of water scarcity. Water stress refers to the state in which water accessibility is limited due to mobilization issues. The threshold value of water is set between 0.2-0.6. Apart from water stress indicators, the water availability index takes into account the monthly blue water availability to the monthly blue water demands of all sectors and compares it. These indicators do not integrate environment flow factors and they also don't assess the non-renewable source of water which is widely used in semi-arid areas, indicators that have the above requirements are very few. It is important to include non-renewable sources of water to develop management policies and plans for the sustainable use of water. The blue water sustainability index (BlWSI) includes both non-renewable sources of water and also non-sustainable usage of water. Effective indicators should be unbiased, address problems, be based on data sources and methods, and be accessible and easily understood[11].

**CHALLENGES:**

An important step in determining our future direction – the challenges we face is to identify the key issues that water resource managers must address today and how these will change over time.

One of the key factors influencing both water quality and quantity is land use management. Changes in available water quantities, adjustments to the frequency and timing of runoff and infiltration, and adjustments to the spatial distributions of available water are all cumulative effects of land use change on water resources that have an impact on both terrestrial and aquatic ecosystems. Water resources are impacted by land management initiatives like hubs and corridors, working lands, and aquifer protection programs. Sustainable water resources management must also include integrated watershed management because changes in land use can either help or hinder sustainable water.

1. **CLIMATE CHANGES:**

Energy production, infrastructure, human health, agriculture, and ecosystems are just a few of the sectors that will be impacted by climate change's effects on water availability and quality. The management of water resources is already under pressure from several factors, including pollution, land use changes, rapid population growth, and damming of rivers. Rainfall is a key climate variable because it is the flux of water from the atmosphere to the surface. The relationship between rainfall rate and all other significant hydrologic variables, including river flow and recharge, is proportional. The distribution of rainfall is likely to change as a result of any significant climate change, and the distribution of all other significant hydrologic variables, including river flow and aquifer recharge, will follow through the water cycle. Due to this, the sustainability of water resources may be threatened by climate change. This might not be true in all scenarios involving climate change. A change in the climate that shifts the distribution of rainfall toward wetter conditions is likely to improve the region's sustainable water resources. The water cycle is impacted by climate change because it alters where, when, and how much precipitation occurs. Over time, it also causes weather events to become more severe[12].

The disruption of the hydrological cycle is the primary impact of climate change on the world's water resources. The increase in temperature consequently causes the amount of water vapor in the atmosphere to increase, the pattern and intensity of precipitation to change, the amount of water evaporating from the earth's surface to increase, the amount of snow cover to decrease, and the melting of glaciers. All important economic sectors are impacted by the effects of climate change on water resources. Both natural and man-made factors may be the cause of climate change. The two main human activities that have a significant impact on the environment are (1) the emission of greenhouse gases, which changes the chemical composition of the atmosphere, and (2) deforestation and desertification, which change the global land cover as it is observed. These two human activities have the potential to significantly alter the climate, which could have an impact on how sustainable water resources are distributed.

Climate change-related thermal expansion of the upper ocean causes sea levels to rise, which in turn causes saltwater to infiltrate freshwater horizons, lowering the quantity and quality of their reserves. In addition to harming fisheries and water intake systems, the movement of saltwater up river mouths also threatens agriculture by causing soil salinization. Rising sea levels will exacerbate conditions like flooding, erosion, and other hazards in the coastal zone, endangering critical infrastructure and habitations and making small islands particularly vulnerable. Rising temperatures cause glaciers and snow cover to melt, reducing water supplies and reducing water availability during warm and dry seasons in areas receiving water from mountain ranges.

Understanding the relationship between finite water resources, climate variability, and different aspects of sustainability is necessary for securing a reliable water supply, which is essential for achieving Sustainable Development Goals (SDGs). A timely and thorough analysis of sustainability as it relates to water resource management in the context of climate change risks is provided in the book “Water, Climate Change, and Sustainability”. The water cycle is impacted by climate change because it alters where, when, and how much recipitation is happening. Over time, it also causes weather events to become more severe[13].

1. **WATER POLLUTION:**

Pollution is a by-product of economic development and continues unabated in many bodies of water due to indiscriminate dumping of domestic, agricultural, and industrial wastes. Many rivers have slowly accumulated pollutants over the years, rendering them anesthetic and biologically and chemically toxic. The introduction of advanced wastewater treatment methods such as membrane technology, recycling, and wastewater recovery helps to alleviate the pollution problem to some extent. In the long term, an integrated approach to water management, where all aspects of the water sector are considered and optimized within a single ecosystem framework, seems the way to go. Pollution has multiple sources and is primarily related to land use patterns and emissions of gaseous, liquid, and solid wastewater. Domestic and industrial wastewater contains potentially toxic compounds and must be treated before being discharged into waterways or the ocean. Gaseous emissions from power plants, mines, and industries combine with atmospheric water to form dilute acids. When it hits the ground as so-called "acid rain", it can have far-reaching effects on soil, vegetation, and water bodies far from the original pollution source. The incomplete removal of phosphates and nitrates in wastewater from domestic, industrial, and agricultural water sources leads to nutrient build-up in downstream waterways.

The sustainability of water resources may be seriously threatened by all human activities that alter the quality of water during the hydrologic cycle. Examples of such activities include the following:

(1) Air pollution from industrial emissions that result in acid rain

(2) Surface runoff pollution from drainage from irrigation plans that use dangerous chemicals like pesticides, and

(3) Contamination of aquifers and lakes from industrial waste discharges.

Adoption of pollution prevention strategies as well as the creation of remediation technologies that deal with contaminated sites may be able to guard against these dangers for sustainable water resources.

The discharge of untreated or partially treated sewage into water bodies, sometimes as a result of improper sewage handling procedures by municipal bodies, is one of the most frequent primary sources of water pollution. In significant cities, this is not unusual. When sewage and other waste are dumped into the water, it causes the water's oxygen levels to drop and promotes algal growth. Seepage pits, garbage dumps, septic tanks, barnyard manures, transportation accidents, and other pollutants pose a threat to groundwater[14].

3. **AGRICULTURAL DISCHARGES:**

Two-thirds of India's agricultural production comes from one-third of its irrigated land. The rest come from wet areas that employ large populations. To meet the growing demand for food and agricultural jobs, India needs to increase irrigated areas and boost productivity in both irrigated and rain-fed areas. In the agricultural sector, water and electricity for irrigation are subsidized for various reasons. This led to wasteful flood irrigation rather than adopting more optimal practices. The excessive use of chemical fertilizers and pesticides has an even greater negative impact on water quality. Chemicals used as fertilizers and pesticides used to fight disease are the two main types of agricultural discharges. Their spills get into water bodies, therefore, pollution has increased as a result of increased production as well as increased use[9].

**4. DRINKING WATER SECURITY**

The cleanliness of drinking water supplies determines the health of the nation. Approximately 1 billion people do not have the means to safe drinking water. This situation is worsened due to improper sanitation facilities. Due to poor sanitation, child death occurs every 20 seconds and the statistics continue rising. This issue is often not given attention as it is only a problem of underdeveloped and developing countries. The effect of lack of drinking water is spread over a vast area. Water scarcity occurs when there's not enough water, poor quality, or due to the inability to store and maintain water. Arid and deserts suffer a lack of water in general and this is intensified due to pollution. Hence traditional methods like using groundwater and non-renewable sources for water are exploited[15].

**5. FOOD SECURITY**

The food intake globally has increased in the last few years and many factors like an increase in land and water productivity, an increase in the global trade of food, increase in population in areas with low productivity, have a role to play. Water sustainability is affected because of changing dietary plans due to lifestyle changes. The water used for the production of food grains, meat, milk, and fish has increased substantially. Many countries have switched from fossil fuels to biofuels which again has exploited the use of water. Rainfall dependant irrigation does not ensure a successful harvest and the flooded mode of irrigation results in the evaporation of the water surface. To efficiently use the water resources, the rate of evapotranspiration must be reduced and this is achieved by the use of drip irrigation, sprinklers, etc[16].

**6. DISASTER MANAGEMENT**

Water is an influential resource and can be used to control various aspects of livelihood. It is said to take over oil as an economic commodity soon. No matter how beneficial water is, it can be destructive too. Floods and tsunami cause various damages and casualties which are alarming and dangerous to humankind. A hazard is referred to as a disaster when the community does not have enough coping mechanism and are vulnerable to such inevitable circumstances. There are various disaster management practices in countries all around the globe, but their practice is slow and influenced by various other factors[17].

**7. EDUCATION**

There should be enough knowledge and exposure provided to all human beings at different levels of life about the water cycle and its relationship with the environment.

**SUSTAINABLE WATER SOLUTIONS: THE BASICS**

Maximize environmental, economic, and social benefits by targeting and selecting projects through a transparent and inclusive process with the community. Achieve consistency across a range of alternatives that meet both utility and community goals and improve the technical, financial, and long-term management capacity of the civil service.

Typically, water utilities have long-term planning deadlines and long-term infrastructure operations and maintenance commitments. Potential costs and benefits of investment decisions made over a long period. As a result, EPA sustainability guidelines require that drinking water and sanitation systems be “strong and comprehensive” so that water infrastructure investments are cheap, resource-efficient, and cost-effective fees throughout the life cycle must be high. Must be consistent with the goals of each community[17].

The following list from IWA explains the sustainable use of different water resources:

**1. Surface water**

Surface water is limited because it is unevenly distributed worldwide and pollution from various activities makes untreated surface water unsuitable for use. If built properly, dams can provide a sustainable source of water as they can be used for power generation, irrigation, flood control, water diversion, and navigation. However, large-scale dam projects can present challenges to sustainability: negative environmental impacts on wildlife habitat, fish migration, flows, and water quality as well as socioeconomic impacts. Therefore, it is necessary to conduct a sustainable impact assessment[18].

**2. Groundwater**

Groundwater accounts for more than 50% of the world's fresh water and is essential for drinking water. Groundwater can only be a sustainable water supply if the amount of water entering, leaving, and storing in the system is conserved. The IWA states that unsustainable use of groundwater leads to reduced water levels, reduced runoff, and poor water quality, with a direct impact on local communities.

Water sustainability also varies across utilities. Some utilities and local governments are incorporating sustainability considerations into their planning processes, but are looking to improve and refine their current efforts. Others may focus on how these considerations can help meet existing regulatory or service requirements cost-effectively[19].

**3. Rainwater:**

Rainwater harvesting is one of the most sustainable sources of water supply, as it creates inherent barriers to the potential for over-exploitation of surface and groundwater resources, and directly supplies water quality drink. However, stormwater collection systems must be properly designed and maintained to efficiently collect water, prevent contamination, and utilize durable treatment systems in the event of contaminated water. There are several methods of on-site drinking water treatment, each with advantages and disadvantages. These include solar treatment, boiling, filter use, chlorination, combined methods such as filtration and chlorination, flocculation, and chlorination. While technically, given the Earth's surface and precipitation, rainwater harvesting could meet global water needs; this solution could be an addition to sustainable water supply systems. Resilient to high levels of uncertainty (especially concerning climate change) and competitive land-use applications[19].

**4. Desalination:**

In some countries without fresh water, desalination has provided enough water for many years. However, the higher energy requirements of heat and membrane treatment compared to ground and surface water treatment have challenged the suitability of desalination as a sustainable treatment method. However, the IWA says the sustainability of the desalination process can be improved if combined with renewable energy. Solar-powered decentralized desalination has been recommended as a way to more sustainably provide water for 6,000 Greek islands[20].

**5. Reclaimed water:**

Recycled water, or water reuse as it is known, can also be a sustainable source of water and can reduce stress on key water sources, such as surface and groundwater. Depending on the given application, reclaimed water must be treated to provide a suitable quality, for example for irrigation or industrial use. The extent of water reuse varies globally. Countries such as Spain and China continue to lead in water reuse, with China accounting for 49% of contract capacity between 2010 and 2017[21].

**SUSTAINABLE WATER MANAGEMENT STRATEGIES:**

Many technologies are employed to preserve water from wastage and loss. They are used to maximize the use of water resources in the country, based on the demand and supply of water, The technologies used differ according to the field of use: domestic, irrigation, or industrial

According to IWA, sustainable water supply is part of integrated water resource management. The association defines this as “the practice of bringing together many stakeholders with different perspectives to determine the best way to manage water”. To decide whether a water system is sustainable, many economic, social, and ecological factors need to be taken into account.

Meanwhile, the United Nations (UN) has identified the following strategies where sustainable management of water resources is needed, in line with the overarching goal of "Ensuring sustainable water for all."

1. **Agriculture:**

Agriculture is by far the largest consumer of water in the world, accounting for 70% of the global watershed, although this figure varies considerably between countries. Rainwater agriculture is the dominant agricultural production system in the world, and its current yields average just over half of the potential achievable under optimal agricultural management. By 2050, global agriculture will need to produce 60% more food globally and 100% in developing countries[22].

**2. Industry and energy:**

Together, industry and energy account for 20% of water demand. More developed countries have much larger rates of industrial freshwater withdrawal than less developed countries where agriculture predominates. The balance between sustainability requirements and the conventional view of industrial mass production creates several puzzles for industries. One of the most important issues is globalization and how to spread the benefits of industrialization around the world without causing unsustainable impacts on water and natural resources[22].

**3. Domestic sector:**

Urban water use accounts for 10% of total water use. And yet, globally, an estimated 748 million people still do not have access to improved water and there is a lack of sanitation facilities for about 2.5 billion people in this world.

**Cities:**

More than half of the world's population already lives in urban areas, and by 2050, more than two-thirds of the world's nine billion people are expected to live in cities. Furthermore, much of this growth will occur in developing countries, which have limited capacity to cope with this rapid change, and this growth will also lead to an increase in the number of people living in the world. in the slums, where living conditions are often very poor, including poverty, water and sanitation facilities. Therefore, the development of water resources for economic growth, social justice, and environmental sustainability will be closely linked with the sustainable development of urban areas.

**Ecosystem:**

Perhaps the most important challenge to sustainable development that has arisen in recent decades is the ongoing global ecological crisis that is becoming an obstacle to further human development. From an ecological point of view, efforts for sustainable development have not been successful. Global environmental degradation has reached critical levels with major ecosystems approaching a threshold that could cause a major collapse. A growing understanding of global planetary boundaries, which must be respected to protect Earth's life-support systems, must be the fundamental foundation of a future sustainable development framework[23].

**4. Desalination:**

Removing dissolved salts from seawater or brackish groundwater is an attractive way to increase freshwater supplies. Distillation and reverse osmosis are the two most common desalination methods. Two other methods are freezing the salt water or running an electric current through it. Distillation heats the brine until it evaporates and condenses as fresh water, leaving the salt in solid form. In reverse osmosis, salt water is forced through a thin membrane at high pressure, allowing water molecules to pass through but not dissolved salts[20].

**5. Cloud seeding:**

For years, some countries have experimented with injecting chemicals into clouds to bring rain to dry areas and snow to mountains. Cloud seeding involves finding a suitable large cloud and injecting it with a propellant like silver iodide from an airplane. Small water droplets in clouds gather around small particles of chemicals to form droplets or ice particles, large enough to fall to Earth as precipitation[24].

**6. RAINWATER HARVESTING**

Rainwater harvesting is the collection of water from the rooftop of buildings and preserving it for future use. It helps in improving groundwater levels by raising the water table which further enhances supply of water. It is crucial to maintain groundwater, prevent movement of water towards lands and preserve surface water runoff during rainy season[25].

**7. BETTER IRRIGATION PRACTICES**

Conservation of water in agricultural sector is crucial because most of the water resources are used here as it helps in the growth of crops. Due to increase in the usage of groundwater and increase in salinity from fertilizers, the quality of water has decreased drastically. Different water harvesting and recharging techniques are applied all over the world to eradicate the problem[17].

**8. USE OF SALINE WATER FOR IRRIGATION**

There are plenty of saline water available but isn't widely used for agricultural purposes as it restricts the growth of plant and also its yield. Various salt resistance plants have been developed in recent times.

**9. FOG AND DEW**

Netting surfaced traps or polyethylene sheets are artificial settings that are exposed to fog and dew to trap water for further use. It principle is based on the ability of fog and dew to condense when in contact with the metallic net. It can be used even in areas with less moisture content. There are also certain plant species that have adapted to use fog and dew.

**10. MULCHING**

It is the use of organic or inorganic components like plant compost, debris to cover the surface of the ground and they are referred to as mulch. It prevents surface run off, decreases evaporation losses, improves soil moisture and soil fertility and prevents soil erosion. Various types of mulch exist, like: like plastic mulch, organic mulch, ornamental mulch.

**11. CONTOUR FARMING**

Used in hills and lowland areas to conserve soil and water. It can be achieved by using furrows, crops rows and wheel tracts all over the slopes. They act as reservoirs to trap rainwater, which allows increased infiltration and consistent distribution of groundwater. Contour farming reduces the impact caused by heavy rains hence preventing major disaster and landslides.

**12. SOAK PIT CONSTRUCTION**

Soak pits are built near water points to prevent water logging and water run offs. This also helps in the increase of ground water. The water undergoes partial treatment and it produces clean, non harmful water which infiltrates into the soil[25].

**13. TREE PLANTATION**

Planting of trees near the banks of river and other water bodies preserve water resources by helping in infiltration of rain water into the soil, preventing water runoff, and preventing disruption of livelihood near river banks by holding streams.

**SUSTAINABLE MANAGEMENT OF WATER RESOURCES:**

Sustainable water strategies will be developed by regional and national governments and will vary depending on many factors: the maturity of irrigation infrastructure, the impacts and risks of climate change, the level of government ambition, regulations and access to finance, among others. According to IWA, sustainability is an outcome as well as an objective. The conceptual framework for sustainable water resource management sees water as a renewable but finite resource with global and regional constraints. This should integrate ecological, economic and social considerations through institutional and legal/regulatory structures toward sustainable water resources.

There are many case studies in which government-led sustainable water management strategies have been developed, taking into account national regulations. Below we've listed examples that vary widely, from city to city and across the country:

**SINGAPORE:**

Singapore has tackled the challenge of meeting its huge water demand of 430 million gallons per day by launching a strategy called Four National Faucets representing four different types of techniques to maintain and recycle. water processing. These include the creation of water plants, the production of water reservoirs, the import of water, and the desalination of the water.

Singapore's first way to regenerate water is through NEWater. NEWater is a treatment plant that recycles used water into clean, safe and recoverable water. They made their public debut in Singapore in 2003 when they first opened two water plants, a visitor center and a water museum. This museum attracts tourists and shows the company's journey in water sustainability. NEWater has three main stages in the water purification process:

The first is called microfiltration or ultra filtration in which wastewater passes through a membrane. This helps filter bacteria and prepares the water for the next stage.

The second stage is called reverse osmosis where a semi-permeable membrane is used. This only allows smaller particles like water to pass through but leaves viruses and other contaminants behind.

The last and final step is UV sterilization which kills all existing bacteria and viruses. While in Stage 2 the water is safe to drink, this is another safeguard.

NEWater currently has five wastewater treatment plants spread across Singapore and supplies up to 40% of Singapore's current water needs. By 2060, it is expected to meet 55% of Singapore's future water needs.

The second country faucet is a tank. Reservoirs are essentially man-made lakes that are used as a source of water. Singapore has a total of 17 reservoirs across the island, and with local catchment techniques covering more than two-thirds of the island's land area, including culverts, canals and small ponds, rainwater is easily transported in the lakes contain. Reservoirs are beautiful places in Singapore that are loved by nature lovers and runners! Marina Reservoir covers an area of ​​590 acres and is Singapore's most urbanized catchment area and meets about 10% of Singapore's water needs.

The next way Singapore manages water is to import water. Singapore has long imported water from neighboring Malaysia. Two agreements have been signed so far. The first agreement dates from 1961 and expired in 2011 and the second agreement was signed in 1962 and will expire in 2061. Under the Johor Bahru agreement, 250 million gallons of water can be taken daily from Johor Bahru to Singapore. Importing countries account for most of Singapore's needs and meet up to 60%. The last and final way is to use desalinated water. Desalinated water turns seawater into drinking water using advanced membrane technology. In Singapore, there are 3 desalination plants and by the end of 2020, there will be 2 new plants. Desalination is energy-intensive, and since Singapore uses reverse osmosis for desalination, 3.5 kWh/m3 of energy is used to make seawater drinkable. Seawater is pushed through the membrane to remove dissolved salts and minerals to create potable water. The Public Utilities Commission (PUB) in Singapore wants to reduce energy consumption and one of the solutions is to use electric deionization. This is where the electric field draws dissolved salts from the water and uses only 1.65 kWh/m3.

While Singapore has many sustainable development techniques that many other countries can learn from, it is important that we as individuals also do our part. While there is not much we can do as students and individuals in the face of these major crises, there are small activities we can participate in to educate others and strive to alleviate some of the harmful effects of water shortages.

CHALLENGES:

Increasing demand and climate change:

Water demand is expected to nearly double over the next 40 years - due to an expected increase in industrial activity and population growth. Coupled with the uncertainty of weather patterns in the face of climate change, we cannot underestimate that we will always have enough water.

Useless Habits:

In Singapore, we are fortunate to have easy access to clean tap water. However, it also allows us to use more water than we need. When clean water flows around the faucet, it's easy to waste water without realizing it.

Wasted water from pipes or water equipment also often goes unnoticed. Loose faucet connections, damaged toilet bowls, and leaky plumbing can all lead to huge water waste. For example, a typical leak from the kitchen could amount to 10,000 liters per year or more than 6,600 large bottles.

OUR EFFORTS:

Technology provides the solution:

To ensure that our desalination processes are as energy efficient as possible, reverse osmosis membrane technology is used as it is reliable and efficient. We are constantly looking for ways to reduce the energy consumption of desalination through investments in research and development.

Limit the impact on the marine environment:

We closely monitor the seawater quality around our desalination plants to ensure minimal impact on the marine environment.

### COUNTRY-WIDE SUSTAINABLE WATER: A LONG-TERM WATER STRATEGY FOR NORTHERN IRELAND

This sweeping strategy focuses on the sustainable management of water in rivers, lakes, lakes and aquifers used for domestic, agricultural and industrial purposes. The document proposes a sustainable way of managing excess storm water at the local level to reduce the impact of flooding on communities. It also looks at how we can reduce the amount of energy needed to move and treat drinking water and wastewater.

STATEWIDE: SUSTAINABLE WATER STRATEGY FOR VICTORIA, AUSTRALIA

Within Australia's statewide statutory water resource planning process, there are four regional water strategies. Driven by the Water Act of 1989, these sustainable water strategies must be reviewed at least every 10 years. The review of the Sustainable Water Management Strategy in the Central Region began in 2016 and is now completed. Five-year assessments of the Western Region and Gippsland Sustainable Water Strategies began in 2017 and have also been completed. The review of the Northern region's sustainable water management strategy is expected to begin in late 2019.

CITY-WIDE: ROTTERDAM – AT THE FOREFRONT OF URBAN RESILIENCE

The Dutch city of Rotterdam tops Arcadis' list of the Water Index for Sustainable Cities. The city has been innovative and proactive in its approach to water management, including investing heavily in the reservoir catchment system. Rotterdam has become an example of urban resilience that leads directly to a sustainable water supply: The city is among the highest in the world in terms of water reserves.

**Urban Water Development**

Access to clean water is one of the most important things for healthy and productive growth. Water and socio-economic development go hand in hand. They can lead to a spiral of hell or reinforce good development practices. Sustainable city growth requires reliable, equitable and readily available water. Bringing water to rapidly growing cities in developing countries is a complex economic and logistical issue. This situation is exacerbated in places where urban development is largely informal and unplanned, making it difficult to predict demand and track consumption. Indicator methods are commonly used to assess the quality of water management in cities. Groups such as the United Nations Center for Human Settlements and the United Nations Environment Program are working to determine how to measure the relationship between urban water management and environmental sustainability. This is an important step in the development of effective indicator methods. Monitoring and evaluating urban water systems in developing regions will help improve the current situation and plan for future development. One review looked at 25 indicators based on four criteria groups: technical, social/environmental, financial and institutional. They found that technical and social criteria are more important to ensure the functioning of a water system than financial and institutional criteria, although they are both necessary. In water-rich regions, the water distribution system is optimized to meet the specified minimum pressure, while in water-deficient regions the goal is to distribute water evenly among users. In the latter case, distribution systems should be designed with the expectation of intermittent operation rather than assuming a continuous supply, thereby reducing pressure problems and distribution inequalities.

Both water-rich and water-scarce regions face challenges in designing water infrastructure and supplies to meet the demands associated with population growth. Infrastructure and operational problems include pipe leaks and "stolen" water in water-scarce areas. Material and construction problems, power supply, or operation and maintenance problems all affect water distribution. Thirty percent of the water systems serving rural sub-Saharan communities are not operational at any given time. Challenges include infrastructural issues, but their origins may include societal and institutional issues related to accountability, knowledge, and coordination.

Regional conflict is a significant challenge to sustainable water management, especially in countries with different levels of development. Melloul and Collin give an example of two local populations at different stages in the water management needs hierarchy. These disparities have led to conflicts over resource allocation and development plans. Political conflicts often lead to increased water tensions and vice versa. The UN has a wide range of programs related to water resource assessment and management, including integrated transboundary water resources management and urban water supply. Recent assessments of cooperation and competition in transboundary water management clearly show cooperation over conflict among riparian neighbors.

More and more sustainable solutions include participatory planning, water collection and reuse. Maintaining a water system requires staff training, supervision, health and safety rules, and communication with users. Sustainable water services should involve the people they serve and use local knowledge of water resources and traditional management practices. The inclusion of women in water management decisions is particularly important in cultural contexts where women have traditionally been responsible for water collection and use, as water management can have immediate and long-term to gender equality.[26].

**PROJECTS:**

**HUAIFANG GROUNDWATER RECOVERY PLANT (HWRP):**

This project was awarded the Gold Medal at the 12th IWA Project Innovation Award under the title “Beijing Sustainable Solution for Ecological Water Reuse”. The 31-hectare wastewater recycling plant is designed to relieve the pressure of sewage treatment in the south of Beijing and improve the water quality of the Liangshui River. The underground wastewater recycling facility will feature four 160-square-foot bioreactors that will produce recycled water that meets the fourth (IV) environmental quality standard for surface water. As an underground wastewater treatment plant, the purpose of the installation is to reduce land use and limit noise and odors emitted from the plant. The gray water will be used for industrial and municipal purposes while the sludge will be treated and reused for landfill and forest land enrichment.

**OMDURMAN WATER OPTIMIZATION PROGRAM, SUDAN:**

One of the most important milestones towards the Millennium Development Goals (MDGs) in sub-Saharan Africa in 2008, the Omdurman Water Supply and Optimization Program was designed to alleviate severe water shortages of drinking water in and around the capital, Khartoum, Sudan. Biwater was awarded funding and built a large-scale water storage, primary distribution, and treatment plant, with an inlet on the Nile, downstream from the confluence of the White and Nile Rivers. Blue. The innovative intake structure was built to reliably handle extreme river level fluctuations, large flows and the large amount of silt carried by the river during the annual rainy season. Interestingly, the innovative water intake structure designed by Biwater to rise and fall on two levels copes with changes of up to eight meters in river level, as well as the weight and intensity of the sediment domestic shipping.

**IMPROVING CONDITIONS IN THE ANDEAN COMMUNITY:**

A project called AICCA is underway in the Andes regions of Peru, Bolivia and Colombia and will focus on drinking water and climate change. The Latin American Development Bank and the Global Environment Fund supported the project with a total amount of 10 million USD. The project aims to address the challenges of climate change, with a focus on water sustainability for the Andean people.

**WATER CONSERVATION PROJECTS AND INITIATIVES IN INDIA:**

The Jal Shakti Department of the Government of India launched the Jal Shakti Abhiyan in 2019. It is a national water conservation campaign to encourage people to participate in promoting water conservation at the local level. The water-saving project was implemented in two phases from July 1, 2019 to September 30, 2019 and from October 1, 2019 to November 30, 2019.

On World Water Day, 22 March 2021, the government launched the campaign 'Jal Shakti Abhiyan: Welcoming the rain' (JSA: CTR) with the theme "Where the rain falls, where does the rainfall". It covers rural and urban areas of all districts of India, during pre-monsoon and monsoon periods, until 30 November 2021. According to the campaign, the government is focusing on creating/maintaining structures that conserve water and collect rainwater, renovate various traditional water reservoirs, reuse and recharge boreholes, and develop river basins and intensive afforestation.

**JAL SANCHAY:**

The Jal Sanchay project is a water conservation initiative started in the Nalanda district of Bihar. The water conservation project focuses on the construction of test dams, silt removal and rehabilitation of irrigation systems and traditional water bodies. It also involves raising awareness of traditional water conservation and rainwater harvesting techniques to maintain groundwater levels. The project is also carried out with the support of local farmers and through campaigns. In 2017, the project was shortlisted for the National Achievement Award under the Mahatma Gandhi National Rural Employment Guarantee Program (MGNREGP).

**Jal Bhagirathi Foundation:**

The NGO is leading efforts to tackle water scarcity in Rajasthan's Marwar region, one of the most densely populated arid regions in the world. NGO focused on restoration and construction of stormwater harvesting structures to replenish groundwater. It also assists communities in the construction of rainwater or tanka reservoirs.

**Living Dreams:**

The NGO is supporting farmers in the Tamil Nadu delta by restoring the ponds that are the main source of water for households, irrigation, livestock, wildlife, and more. It also focuses on improving farmers' livelihoods, by increasing groundwater levels. level and fight against water scarcity. Environment Fund of India:

It is an environmental conservation group that focuses on conserving wildlife and restoring freshwater habitats such as lakes and ponds through scientific means. Some of the water conservation projects undertaken by the organization include the restoration of the Kinhi-Gadegaon Reservoir in Maharashtra, Lake Tirunelveli-Keezh Ambur in Tamil Nadu and Navule Kere in Shivamogga, Karnataka.

**Tarun Bharat Sangh:**

Tarun Bharat Sangh is a non-profit environmental NGO that aims to achieve water conservation goals by involving the community at all stages of development work and by applying best practices. indigenous water extraction. This NGO has revived ten rivers and transformed 10,000 square kilometers of drought-prone areas in Rajasthan, one of India's most water-scarce states.

**SARA (Sustainable Alternative to Rural Agreement):**

The organization led the Swagrama program and worked on different levels of practice to understand and implement sustainability models. This water saving project is inspired by Mahatma Gandhi's dream project, "Village Swaraj", and aims to achieve autonomous rural development.

**HOW TO ACHIEVE WATER SUSTAINABILITY?**

There are three key aspects needed to achieve water sustainability, which are:

- Resilience

- Effective

- Quality

**Resilience:**

The scope of resilience is not only about structure and protection, but also about disaster recovery. Resilience extends to the 'soft' infrastructure of society, including employment, income distribution, social cohesion and other factors that are not normally integrated into water management.

Green space and multi-purpose urban solutions:

Many cities are turning to green infrastructure projects to manage storm water problems as an alternative to traditional piped drainage methods. Green infrastructure can provide valuable green space and recreation for city residents, reduce urban heat island effects, and improve biodiversity and ecological resilience.

**Efficiency**

***Optimization of Urban Water Use***

Optimization of water resources starts with a good knowledge of assets, system performance and the types and levels of usage, both current and projected. Combining this information with knowledge of the system’s vulnerabilities, risks and stress points lead to actionable plans that can help utilities produce greater efficiencies.

***Urban Asset Preservation and Management***

Aging urban water infrastructure poses a serious challenge. Deferred maintenance and spending have resulted in a major funding gap. Risk-based asset management approaches are increasingly being used to prioritize capital and operating investments.

### **Water Quality**

Water quality is arguably where urban sustainability performance is highest, since drinking water plays such a critical role in quality of life. Cities in the developed world have historically improved their prosperity and economies only after adequately addressing water quality and sanitation. Cities in the developing world, however, will need to improve water quality to become prosperous, sustainable urban centres.

# **25 WAYS TO SAVE WATER:**

1. Check on toilet leaks:

To check leaks in the toilet bowl, add a few drops of food coloring. Without rinsing, stains start to appear in the bowl, and you have a leak that can waste over 100 gallons of water per day.

2. Stop using your toilet as an ashtray or trash can:

Each cigarette butt or handkerchief you flush also releases 5 to 7 gallons of water.

3. Put a plastic bottle in your toilet:

Place an inch or two of sand or gravel in the bottom of a quart bottle to weigh them down. Fill the rest of the bottle with water and place it in your toilet bowl, safely away from the operating mechanism. In an average home, bottles can save 5 or more gallons of water per day without affecting the efficiency of the toilet. If your tank is big enough, you can even put two bottles in it.

4. Shorter shower:

A typical shower uses five to ten gallons of water per minute. Limit bathing to the amount of time it takes to soap off, shower, and wake up.

5. Install a water-saving shower or a flow-limiting device:

Your hardware or plumbing store stocks inexpensive showerheads or flow limiters that will reduce your shower's flow to about three gallons per minute instead of five to ten. They are easy to install and your shower will stay clean and refreshing.

6. Take a bath:

A partially full bath uses less water than all but the shortest showers.

7. Turn off the water while you brush your teeth:

Before brushing your teeth, wet the brush and fill a glass to rinse your mouth.

8. Turn off the water when shaving:

Fill the bottom of the sink a few inches with warm water to rinse your razor.

9. Check faucets and pipes for leaks:

Even a small drop can waste 50 liters or more of water per day. 10. Only use the automatic dishwasher at full load. Running your dishwasher less often saves water and money.

11. Only use the automatic washing machine at full load:

Your automatic washing machine uses 30 to 35 gallons per cycle.

12. Do not leave the faucet running while you are washing vegetables:

Instead, wash your vegetables in a bowl or tub filled with clean water.

13. Keep a drink bottler in the fridge:

This puts an end to the wasteful habit of using tap water for cooling and drinking.

14. If washing dishes by hand, do not allow water to run into the dishwasher:

If you have two sinks, fill one sink with rinsing water. If you only have one sink, collect all your washed dishes first in a rack, then give them a quick rinse with a hose or basin of water.

15. Check faucets and pipes for leaks:

Sewage leaks 24 hours a day, seven days a week. Usually, an inexpensive washing machine is enough to prevent them.

16. Water your lawn only when it needs to be:

Regular watering does not allow for cool or rainy weather, reducing the need for watering. Walking on the grass. If it stands up when you move your legs, it doesn't need water.

17. Soak Your Lawn Deep:

When you do water your lawn, water it long enough for water to seep down to the roots where it is needed and not light sprinkles as those waters evaporate. When you water your lawn, water long enough for the water to seep down to the roots where it's needed. Light watering lying on the surface will simply evaporate waste.

18. Water at cooler times of the day:

Early morning is better than evening because it helps prevent fungal growth.

19. Don't water the gutters:

Position the sprinkler so that the waterfalls on your lawn or garden, are not in unnecessary areas. Also, avoid watering on windy days, as much of your water can be washed away on the streets and sidewalks.

20. Planting drought-resistant plants and crops:

Many plants are beautiful and thrive without irrigation.

21. Put a layer of humus around the trees and plants.

Much slows down the evaporation of moisture.

22. Use a broom to sweep driveways, sidewalks and steps:

Using a faucet wastes hundreds and hundreds of gallons of water.

23. Do not flush the faucet while washing the car:

Soap your car with a bucket of soapy water. Only use the faucet for rinsing.

24. Tell your child not to play with faucets and sprinklers:

Children love to play under the faucet or sprinkler on a hot day. Unfortunately, this practice is extremely wasteful of precious water and is not recommended.

25. Check for leaks in pipes, hoses, faucets and fittings:

Leaks outside the home are easier to overlook because they don't stain the floors or keep you awake at night. However, they are even more useless than indoor water leaks, especially when they occur on your main water line[27].

**CONCLUSION:**

Sustainable water management of urban, agricultural and environmental systems is an integral part of continued development. Many models and measures exist to evaluate sustainability management practices. Improvements to these methods should focus on the interdependence of social and physical systems using robust quantitative measures. Urban water management in developing regions faces equitable distribution challenges, especially in the context of rapidly growing urban populations. Sustainable management plans should focus on continual improvement of stakeholder engagement and infrastructure in developing regions, as well as water extraction and reuse in regions. develop. Reusing water will reduce stress in times of drought, although the costs and risks of adopting this technology remain barriers in developing as well as developed countries. Improving crop water productivity can benefit all water users discussed in this article by reducing competition between the agricultural sector and urban users and the environment. Crop water production in irrigated areas can be improved through changes in crop water allocation and the adoption of efficient and on-farm irrigation technologies, while in Rainwater-driven agriculture would benefit from additional irrigation. Maintaining a sustainable water supply in natural systems can be seen as contradictory to development practices if only the short-term future is considered. Long-term economic development is clearly linked to the health of environmental systems, as evidenced by the emphasis in developed countries on restoring and protecting water resources. In the application, decisions based on the estimated value of ecosystem services can be used to set environmental degradation thresholds, in the context of economic and social development goals. Sustainable water management will vary by geography and economic viability, although all regions can manage water resources in a way that supports socially, economically and environmentally sustainable development.

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