Chapter

Achieving Sustainable Development Goal Related to Water and Sanitation through Proper Sewage Management

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Abstract

Due to urbanization, there is an increasing need for infrastructure and services, leading to pressure on the sewage system. As a result, water contamination and sewage-related illnesses are emerging. On-site sanitary facilities are insufficient, and current sewage systems are outdated, causing freshwater contamination and diseases such as typhoid, malaria, etc. Untreated domestic sewage/wastewater, mining waste, industrial wastewater, agricultural waste, and other contaminants are polluting most aquatic ecosystems worldwide, leading to harm to surface water bodies, sewage drainage systems, surface water, and groundwater. Various sewage disposal methods are discussed, but they are not sustainable. The UN proposed Sustainable Development Goals (SDGs) in response to the need for sustainability and the effects of pollution and population growth. SDG 6 aims to ensure equitable access to safe and affordable drinking water, sanitation, and hygiene. It also includes goals to enhance water quality, increase water usage efficiency, develop integrated water resource management, and restore aquatic ecosystems. Efficient sewage disposal is crucial to reduce detrimental effects on the environment and public health. It is necessary to emphasize SDGs to protect the environment sustainably. It is crucial for the international community to work together to find effective and sustainable solutions to the problem of sewage management.

Keywords: sewage disposal, sustainable development goals, sanitation, eutrophication, contamination

1. Introduction

Water scarcity is a major global issue. It is so relevant that United Nation has given priority to water management across the globe. Similarly, India also is dealing with water crisis and there is a growing need for freshwater at household and commercial level. As per the latest reports by the committee of the Ministry of Water Resources (2000), India is overall consuming 1093 billion m^3 and this consumption will increase to 1447 billion m^3 by the next 30 years. The common man is enraged and agitated about the pollution issues in India and worried about it getting worse each passing day. Negligent disposal of industrial and domestic wastewater is polluting the waterbodies of India. In Indian culture, the water bodies are not only the source of life but are considered very sacred. Indians are religiously sentimental about the water bodies of the nation are getting serious about their detriment [1].

Population wise India wears an inglorious crown as a second-highest population on the entire planet. India is known as a land of agriculture, thus 93% of freshwater water goes in agricultural practices and remaining 7% is consumed by industrial and domestic processes. Due to consistent utilization of surface freshwater, currently in India, the three fourth of freshwater bodies are now contaminated by the discharge of untreated sewage wastewater. Owing to regrettable sanitation practices, 80% of the total water consumption of Indian subcontinent is returned as wastewater, polluting the waterbodies and soils.

As per recent reports by environmentalists and environmental scientists, many major Indian cities and suburbs are facing persistent issues in the matter of solid liquid waste management including sewage management, especially in rural areas. Current situation of rural India paints a really bad picture of sewage and sanitation management. Villages of the country are still lagging behind in the matter of proper sanitation practices and better sewer lines in domestic surroundings. Mixing of sewage waste in open freshwater is a major cause of pathogenic contamination in domestic water supplies and diseases related to it. Water borne pathogens are responsible for approximately 3.5 million human deaths as per recent reports by UNDP [2]. According to a report of WHO-UNICEF, Indian villages contributes to more than 50% open defecation practices responsible for many health concerns including high infant mortality, spread of water-borne diseases and child stunting [2]. Freshwater bodies such as lakes, rivers, ponds and groundwater are getting contaminated by sewage due to ignorant open defecation practices in their catchments.

Similar situation is recognized in urban settlements as well, according to some recent reports, urban domestic sewage is a primary cause of decline in aquatic freshwater ecosystem of India. On account of inadequate treatment systems in most the Indian cities, untreated or half treated sewage run offs are fusing with the natural water resources, also contaminating the rivers of cities with effective treatment plants as well. Domestic sewage contributes more than 70% of total pollutants in water as per reported in Water Aid (2016a) [1].

Domestic sewage from major cities and towns of north India alone contributes for the 1528 million m^3 sewage waste along the banks of the river Ganga every day. Unfortunately, due to ever growing population and urbanization along with the languid implementation of Government policies, the sanitation practices are still not on the path of any improvement [3].

In developing nations, sewage or domestic wastewater is main source of water supply due to growing water scarcity but to avail that water, it needs to be properly treated and analyzed before use. Owing to lack of awareness and improper treatment methods, maximum population is consuming this contaminated water on daily basis which is posing serious threat to the community as a whole. The gray wastewater constitutes the washes coming out from households, institutions, industries, business establishments etc. However, the main constituent in sewage wastewater is fecal matter of human and animal activities. Due to the presence of fecal matter, sewage water is rich in organic compounds and pathogenic enterobacteria [4].

Organic wastes, mainly in the form of sewage sludge is recently been considered an important resource available to meet the ever-increasing demand of renewable energy across the globe. Organic compounds can be employed as a resourceful substrate to generate energy in the form of heat and can be utilized in advanced new age technologies as well. In addition, the organic contaminants in sewage can be used as a source of fertilizers for soils and bioremediation of infertile lands [5]. But most of the time these organic contaminants are considered pollutants and cause serious harm to the ecosystem.

In lieu of changing environment and challenges posed by water scarcity and growing demand of clean and hygienic water for consumption, United Nations (UN) general assembly reinforced the Agenda 2030 for sustainable development in September, 2015. Out of 17 Sustainable Development Goals (SDGs) defined for different societal issues, SDG 6 was dedicated completely to the access of clean and adequate water to every individual. The United Nations Environmental Program (UNEP) adopted SDG 6 as clean water and sanitation, which is subdivided into targets to be achieved by the end of 2030. The main elements of the SDG 6 include the availability of quality water to each individual, treatment of wastewater, efficient use of available freshwater, integrated water resource management and sustainable ecosystem. In totality, the SDG 6 aims to ensure the sustainable management and availability of proper sanitation and clean water for one and all by the end of this decade.

These diverse set of objectives is a reflection of the growing realization that a lot of problems with water management, adaptability, and administration must be rectified if the humanity ought to be experiencing overall growth in sustainable manner [6]. In order to achieve Sustainable Development Goal 6 (SDG 6), it is essential to carefully monitor and evaluate social and fiscal water demand at the regional level in a way that does not harm the environment on global scale. India holds a crucial position among developing nations with a complex interrelated web of a rapidly expanding population, geophysical pressure, social insecurity, and economic disparity pertaining to the usage, availability, and access to water and basic sanitation systems [7].

2. Evolution of sewerage systems

"The history of men is reflected in the history of sewers" famously quoted by Victor Hugo in 1892 in his equally famous literature "Les Misérables". He claimed that "it has been a sepulchre, it has served as asylum, crime, cleverness, social protest, the liberty of conscience, thought, theft, all that the human law persecutes or have persecuted is hidden in that hole."

It is well acknowledged that people's interactions with sanitation and drinking water have changed significantly over time as a consequence of societal, cultural, and religious factors. Urban communities have been conscious of the need for potable drinking water since ancient times. However, modern communities did not entirely comprehend the significance of basic sanitation for the safeguarding of public health until the 19th century. Historically, for both individuals and governments, managing wastewater had always presented political challenges and substantial need for technological advancement. The history of waste and sewage management is a reflection of both human brilliance and human frailty. The progress of sewage management over time has been addressed by many economists and scholars, but it is common that they typically lack an engineering insight on the issue.

Evolution of sanitation and sewage management over time is divided into few significant eras to understand the development of sanitation methods chronologically:

1. **Ancient Civilization**: The early human populations were distributed over vast areas, and the waste they produced was sent back into the environment where it was decomposed by organic processes. Disposal problems were essentially non-existent since they were small groups of wandering hunters and subsistence farmers. Raw sewage was discharged through holes made in the ground and closed after being used, in accordance with the Mosaic Law of Sanitation, until the initial developed civilization emerged [8, 9].

2. **The Time of Romans**: The Romans carried on the Assyrian engineering endeavors and put their concepts into practice to create a substantial infrastructure system to serve the entire community. The Romans built two networks to collect spring water and remove storm and effluent, thus creating the first integrated water service and controlling the water cycle from collection to disposal. The Romans recognized that surface water could be utilized for other things outside human consumption and that spring water was of far higher quality than surface water. They also recycled spa effluent by using it to flush bathrooms before disposing of the waste in sewers, which eventually led to the Tiber River. Ancient Rome had a very complex sewer system that was made up of multiple smaller sewers. Although, sewer and water pipes were already present in other Eastern civilizations, Romans did not create them, but they probably made significant improvements.

3. **The Era of Sanitary Downfall**: While the magnificent water distribution systems which would have established the Romans famous for generations were neglected, the huge baths were robbed of all of their belongings. Water started to be collected from streams and aquifers and dumped without even being treated, which was a historically unprecedented step in the wrong direction and caused disease to proliferate. Several thousand years passed during the unsanitary dark ages (476–1800).

4. **The Industrial Age:** The industrial revolution and the subsequent high pace of industrial growth during the 18th century led to an understanding of the significance of waste and sewage disposal. The experiment with organized action to enhance urban environmental conditions started in Britain, one of the first nations to do so. The Bazalgette sewerage system in England, which was built between 1858 and 1865, is a perfect demonstration of this concept. Wastewater was transported from the streets and then released into the Thames by a network of collection sewers and reservoirs. No one understood the river's capability for assimilation or the necessity of removing pollutants before releasing them into the stream.

In Frankfurt, the development of a system in 1867 marked the beginning of the widespread installation of sewers in German cities. The reconstruction of Paris began in June, 1853, when George-Eugene Haussmann took his oath of office as prefect of the Seine. Eugène Belgrand was given the task by Haussmann of conducting a significant restructuring of the city's existing sewerage system beginning in 1854.

The Pugliese Aqueduct, which brought water from the Sele River to Bari, was the last of the major public works projects in Italy that were built between 1870 and 1915. These projects included the aqueducts of Serino and Selino. Almost invariably, building aqueducts for "aristocratic" drinking water was favored over building sewers to collect effluent, partly because the cost of aqueducts was relatively low due to the reusing of old Roman pipeline infrastructure and the construction & maintenance were funded by overseas companies.

The construction of "sewers" utilizing hollowed-out logs began in the 1700s in large towns like Boston and Chicago. The first "water pollution control" law was implemented in Massachusetts, a British colony, in 1647.

5. **The Era of Strict Environmental Regulations**: The twentieth century ultimately saw a breakthrough in environmental research, sewage treatment, and people's sentiments towards pollution. Throughout the century, scientific advancement, societal values, and government actions changed, starting with unregulated pollution and concluding with efforts to strengthen control (10).

The 8th Report of the Royal Commission on Sewer Systems in 1912, established rules and Biochemical tests to be performed on sewage and sewage sludge and introduced the idea of biochemical oxygen demand (BOD), was a defining moment and was already imitated by many other nations.

Scientists were capable of predicting the permissible limits of BOD loads to surface freshwaters owing to the creation of aeration/deaeration models by Streeter and Phelps (1925) and later developed by Imhoff and Mahr (1932) [10, 11]. Meanwhile, authorities made waste management mandatory. Wastewater treatment plants were built in the major cities of Europe prior to the World War I, but warfare contributed in their construction to be suspended [12, 13].

However, political ideologies in several nations impeded the management of sewage. For instance, when the national socialist party was elected to power in Germany, they changed the way wastewater was handled. The "Blood and Soil" philosophy emphasized agricultural exploitation over eliminating the contaminants before use, resulting in massive irrigation of sewage wastewater for agriculture practices.

Later on, the World War II also slowed down the sewage treatment systems till 1948, resulting in increased water pollution. Furthermore, several wastewater treatment facilities suffered damage during the conflict and were never repaired [12].

The United Kingdom and the United States saw tremendous advancements in sewage waste management after the war, but not Europe [13]. Pollution discussions by 1950 were centered on stream use categorization and freshwater quality standards, which were prerequisites to the development of a strategy for sewage management [14]. The general relationship between industrial water pollution and toxicity was established as early as the first decade of the 20th century [15].

In the late 1970s, publicly available gas chromatography and atomic absorption spectrophotometry techniques contributed to the further advancement in our knowledge of environmental pollution [16, 17]. This made possible to identify environmental contaminants accurately. In the early 21st century, a roadmap for the advancement of analytical techniques was established [18].

3. Access to sanitation: current Indian scenario

The extent to which modern sanitation systems are utilized is significantly influenced by the availability of water [1]. In metropolitan areas, over 90% of individuals have safe drinking water, and therefore more than two-thirds have access to basic sanitation facilities, based on research by World Bank in 2011. Access to reliable, cost-effective, and sustainable water supply and sanitation (WSS) services, however, is still a challenge. None of the Indian cities have constant piped water access. Flowing water is never delivered for more than a few hours on daily basis, regardless of the quantity supplied. Untreated sewage regularly spills in exposed sewers. Those who live in cities make up only about half of the population. Between 30 and 70 percent of the water delivered is thought to be non-revenue water, which is caused by leakage, faulty connections, inefficient billing and collection practices, etc. Less than 30–40% of maintenance and operational expenses are covered by user fees. The bulk of urban businesses depend heavily on grants for operating and capital to survive [19].

4. The untold story of pits in urban India

A flushable toilet has come to symbolize modern urban population living in India and throughout the world. More than 80% of Indians living in metropolitan areas have access to solitary or communal bathrooms. Instead of being linked to a sewer network, most of these toilets are pour-flush and joined to a pit or septic systems. In the absence of pipes to remove fecal waste from pits and tankers, it ought to be transferred by non-waterborne methods. Until about the mid-2000s, most pit cleaning work was done by hand. Waste is discarded distant from households in the caste-based practice of manual "scrounging" after being scraped out of dried, unsewered lavatories. Due to recurring sanitation employee fatalities as well as the vile aspect of manual scouring, the Indian government approved the "Prohibition of Employment as Manual Scavengers and their Rehabilitation Act" in 2013. For collection, a water tank with a sturdy, leak-proof design is a requisite [20].

The basic treatment system, or septic tank, lowers the biochemical oxygen demand (BOD) by 30 to 50 percent on average while minimally affecting the pathogens and nutrient content. The wastewater from the tank therefore has to be remedied further, either with underground dispersion systems or impenetrable secondary and tertiary treatment methods. Conventional septic tank systems, also known as "septic systems," include a septic tank and a subsurface dispersal mechanism, like a soak pit and dispersion trench. The soak pit plan has obstacles due to costs, close communication with the septic tank, and associated activities.

Due to a shortage of consistent desludging solutions, families opt for bigger septic tanks which needs less frequent desludging. However, 67% of pit latrines larger than 2000 L only have one compartment, rendering them inefficient for their intended use. The construction of a subsurface dispersion system in addition to the onsite repair of the basic unit would be required in order to handle wastewater through soak pits under these circumstances [21].

5. Deteriorating health status

Water availability is essential for human life. According to the report published in 2021 on World Water Development by UNESCO, water usage has increased exponentially in the previous century and it has increased by about 1% each year since the early 1990s. As a consequence of increased water consumption, water quality is experiencing serious crises. Human wellbeing and long-term socioeconomic development are eventually harmed by environmental pollution and degradation forced by urbanization, subsistent agriculture, and rapid industrialization, which have detrimental effects on the rivers and streams that are critical for health of ecosystem [22]. In recent reports of 2022, WHO estimates that 8,29,000 individuals annually die from acute diarrhea as a consequence of inadequate hygiene practices, sanitation, and potable water. However, diarrhea is generally avoidable, and by addressing these health risks, 2,97,000 newborn fatalities under the age of 5 might be avoided annually [23].

In India, the pathogens mostly responsible for water-borne infections include the bacteria *Escherichia coli*, *Vibrio cholerae* and *Shigella*. Other than that, parasites such as hookworm, *Entamoeba histolytica* and *Giardia* as well as the viruses Hepatitis A, poliovirus, and rotavirus are also responsible for the diseases. The presence of chemicals in the water are known to cause health issues as well. Pesticides which are washed into streams as well as other sources of fresh water can also harm the nervous, endocrine, and reproductive organs.

Phosphorus, organophosphorus, and related compounds can all cause cancer. Infants who are consuming milk are usually diagnosed with blue baby syndrome if nitrate toxicity in drinking water is present. Similarly, Lead contamination affects the central nervous system. Malignant melanoma and complications related to it are both brought on by arsenic poising. Fluoride contamination can damage the nervous system and lighten teeth color. The use of petrochemical products can cause cancer even in little dosages [1]. Skin problems such as melanosis and keratosis are connected to the high arsenic levels in water supply, main cause of water poisoning in Bangalore, as per reported by Kazi *et al.* in 2009 [24]. According to a different study carried out in Bangladesh, stream pollution is a significant contributor to the prevalence of scabies there [25]. Nitrate was the leading contaminant in India in 2019, and it was discovered in 387 districts. India has been ranked 120 out of 122 nations in regards to water quality, having 70% of the country's fresh water being assessed to be highly polluted, as per Niti Aayog [26].

6. Economic and environmental sustainability

The injudicious utilization of freshwater and common wastes from residential, farming, and manufacturing sector in natural lakes and rivers has exacerbated the challenges related to purity, cleanliness and availability, of water supplies. It has been determined that contaminants such as oxygen-demanding substances, diseases causing microbes, micronutrients, minerals, and synthetic organic substances are possible contaminants of municipal effluents.

Ingredients like ammonia in freshwater sources that need oxygen may endanger the aquatic ecosystems. Pathogens are introduced into the subsurface waters via sewerage from municipal wastes, storm water runoffs and industrial effluents. Substantial levels of nutrients including carbonates, nitrate, and phosphate are present in farm effluent. High nutrient levels, particularly those of phosphate and nitrate, if improperly managed, can lead to enrichment, which encourages the proliferation of algae and ultimately result in eutrophication of waterbodies. Hence, prior to getting dumped into the water system, effluent must always be monitored and treated to prevent harm to aquatic life and natural reservoirs [27].

The easy accessibility to sewage treatment plants is already present in urban areas, however, even there in the first, the amount of sewage generated as well as the amount handled varied significantly. The nation's expanding economic and population growth are surpassing the development of water infrastructure in India's key areas. Treatment systems for wastewater should be also be ecologically acceptable for wholesome development. But environmental sustainability and efficiency of wastewater treatment systems is significantly hampered by commercial feasibility. Elevated levels of wastewater treatment may boost the cost of the infrastructure without necessarily improving the benefits, especially the immediate monetary rewards, that would be counterproductive to the facility's capacity to generate a profit. There are trade-offs between wastewater treatment technologies' economic and ecological efficacy. High levels of sewage treatment, which seem to be expensive, could not produce comparable economic advantages by minimizing the impacts of treating wastewater just on ecosystem [1]. India today has a fast-growing population, an unproductive infrastructure, ecological degradation, and social inequality. The concept of sustainable development, which is described as "development that addresses present needs without jeopardizing the ability of future generations to fulfill their own needs," was developed to minimize the above-mentioned effects [7].

7. Sustainable development goals

The United Nations adopted seventeen Sustainable Development Objectives in addition to 169 other goals in 2015. The Sustainable Development Goals (SDGs) cover three main areas of holistic development such as the environment including climate change, aquatic ecosystem, land ecosystems, etc.; society including poverty, malnutrition, non- discrimination, equality and security, institutional mechanisms, etc. and economic growth including reduced injustices, steady work, and economic expansion, etc. [28]. Out of these 17 goals, Sustainable Development Goal 6 is dedicated to access to clean water and sanitation for all.

8. Sustainable development goal 6

Access to proper sanitation and safe drinking water is the major health intervention that offers the greatest economic benefits as well. Nearly half of all the instances of malnourishment are caused by lack of safe drinking water, unhygienic environment, and inadequate sanitation. A further issue is the continuing decline in water purity and growing scarcity. By 2050, it has been predicted that at least one fourth of total world population would live in a country with persistent or long-term freshwater scarcity, affecting over 2 billion individuals currently. It is vital to put measures in place that will ensure human utilization of water is sustainable and environmentally efficient. In light of this, SDG 6 includes far greater array of water related targets than just improving accessibility [29] **(Figure 1)**.

SDG 6 is essential since it also affects some other SDGs directly, such as SDG 1 (No Poverty), SDG 2 (Zero Hunger), SGD 3 (Good Health and Wellbeing), SDG 11 (Sustainable Cities and Communities), SDG 14 (Life Below Water) and SDG 15 (Life on Land) [18]. SDG 6 contains eight targets, all of which deals with different challenges regarding water [6].

As per the recent reports by Integrated Water Resource Development, India would likely require more than 900 billion m^3 of water in a low load situation and more than 1000 billion m^3 in a peak load situation by the end of the year 2050. The nation's present water supply is 695 billion m^3, whereas the current sustainable groundwater availability has been estimated to be 1137 billion m^3.

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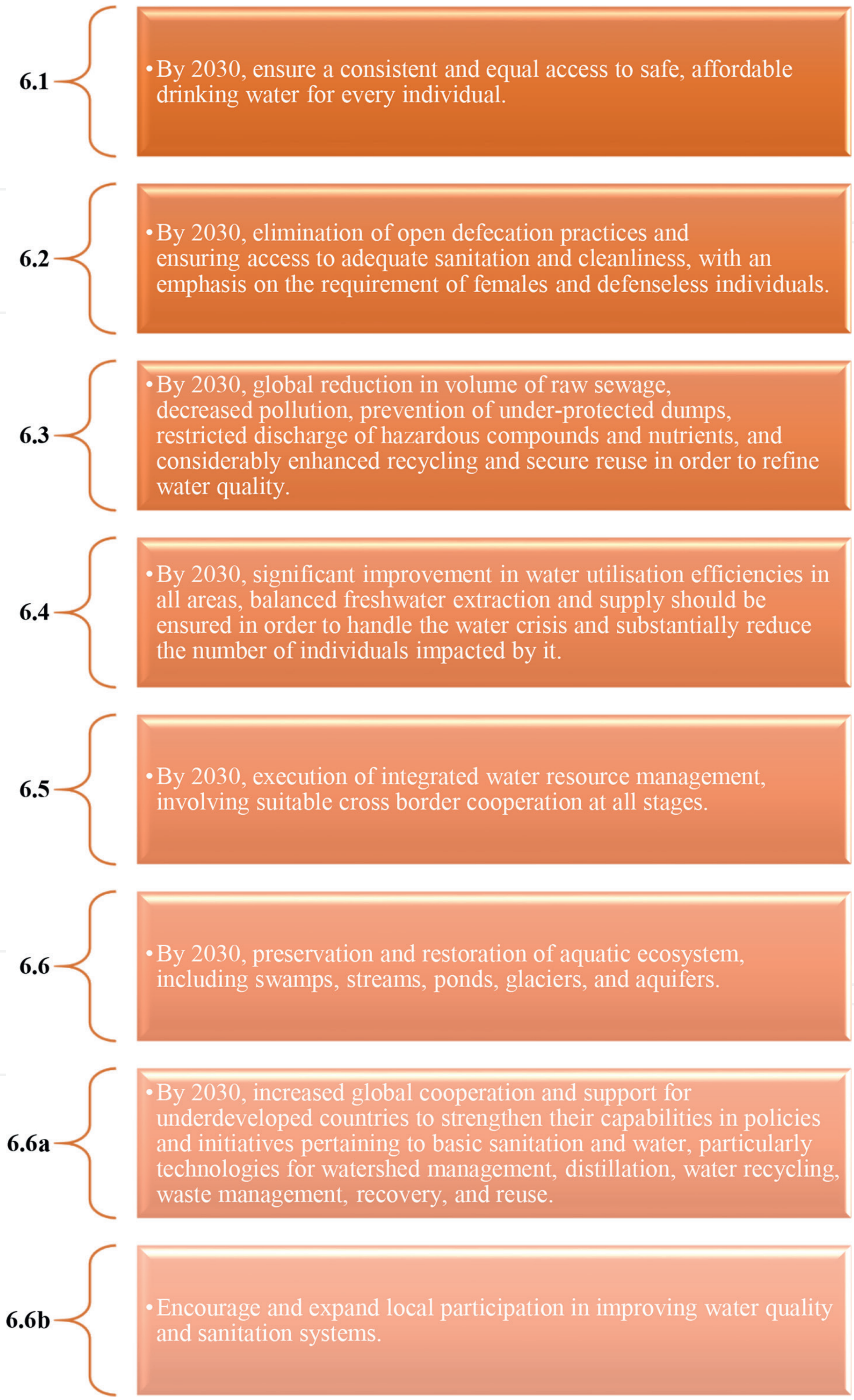

Figure 1.
Targets of SDG 6 to be achieved by 2030.

6 billion population in India endure mild to severe shortage of water, and fluoride poisoning of aquifers has already been found in 184 regions, based on a recent study by the Green Governance Initiative [6]. It is crucial for India to start advancing towards achieving SDG 6 tragets as early as possible to combat the growing issues of water scarcity and poor sanitation among others.

9. Feasibility of SDG 6 in India

Innovation, technology, and materials engineering advancements offer tremendous opportunities to accelerate the implementation of SDG 6. Science solely, however, cannot tackle all of the country's water-related issues. To accomplish SDG 6, three important pillars have been devised which includes sustainable management, science, and commerce. The economic approach towards freshwater scarcity, opportunities, and pollution cost has been given a little value. Due to its scarcity, water must be regarded as a non - renewable resource and its utilization should be controlled keeping in mind the sustainable approach.

In addition, the traditional approach to water management and architecture has to be reassessed. India's water technologists must design strategies which reuse sewage and other wastewater and differentiate between the water resource coming from different sources, expenditures, qualities, and dependability, each utilized for specific requirements and objectives. This necessitates a variety of local suppliers as well as the use of strategic planning, circularity, decentralization, and potential for eco-friendly alternatives.

In order to take connections, unpredictability, and transitions into account, management of water resources must be flexible and interconnected. Using integrated strategies makes it simpler to identify market, mitigate them, and comprehend unexpected consequences. They also enable integrated water infrastructure by drawing together numerous sectors and partners at all levels, spanning between regional to cross-border [30].

10. Conclusions

Management of sewage runoffs is a topic which is becoming ever more relevant. Developed economies are now stretching the purview of wastewater management to incorporate the elimination of trace nutrients and organic compounds in addition to the elimination of carbon - containing contaminants. Eventually, treatment facilities must provide discharge that would be suitable for direct water consumption. Considering the potential of recent technological advances, this seems to be feasible and will therefore spread across the globe. It's indeed crucial to comprehend the physical and chemical properties of wastewater in order to devise an adequate sewage treatment system, select a suitable approach, establish minimum standards for the remnants, ascertain the degree of assessment required to verify the system, and choose the byproducts to be assessed based on the level of toxicity.

As a nation with growing water issues and ever-growing population, India must reconsider its current assumptions and how we perceive and use water in order to meet the targets regarding SDG 6. We cannot continue to think of safe drinking water as something of an excessively abundant and affordable resource. We will be required to employ a considerable measure of creativity, analysis, and ingenuity to come up with solutions that preserve and design water resources environmentally, while also attempting to utilize water efficiently and equally. This same outcome of Sustainable Development Goal 6 (SDG 6) calls for sustainable improvement in the fields of clean water supply and basic sanitation, that further necessitates proper scrutiny and understanding of societal and economic need of potable water at the nation's level in a manner that ought not to propagate adverse environmental consequences on the regional and global levels.

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Conflict of interest

The authors declare no conflict of interest.

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