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REVIEW PAPER

Survey on The Challenges for Achieving SDG 6: Clean Water and Sanitation: A Global Insight

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Abstract

Achieving the Sustainable Development goal 6 (SDG 6) remains a significant challenge, especially in developing countries where limitation of resources, inadequate infrastructures and environmental pressures are widespread. This review paper examines the studies published between 2010–2024 to focus on key challenges that prevent the progress towards SDG 6, including insufficient infrastructure, climate change impacts, rapid growth of Urbanization, low public awareness regarding the SDGs, and limited financial funds available. The findings of this paper show that funding gaps and insufficient infrastructures remain a great challenge particularly in low-income countries, where access to clean water and sanitation is crucially low, funding gaps in developing countries further hinder the progress of SDG 6. Climate change exacerbates water scarcity, and the water quality is degraded through climate impacted pollution, extreme weather events and pressure on groundwater resources. Further water resources are reduced due to the impact of urbanization through reduced ground water recharge, increasing demand, and deteriorating pollution, particularly in rapidly growing cities and urban slums, Moreover, low levels of public awareness and reluctance to support sustainable water management practices hinder community engagement, which is essential for achieving SDG 6 goals. The paper concludes with a call for action, urging policymakers and stakeholders to implement sustainable solutions, promote cross-sector collaboration, and prioritize investments in water and sanitation infrastructure. Only through comprehensive and coordinated efforts can equitably access to clean water and sanitation become a global reality.

Keywords: Sustainable Development goals; Water quality; Public awareness; Clean water and sanitation.

1. Introduction

1.1 An overview

The 2030 Agenda for SDGs adopted by united nations in 2015, provides a blueprint now and in the future for peace and prosperity for people around the world, comprised of 17 SDGs which is a call

for action by all nations around the world [1]. Among these, SDG 6 aims to provide clean water and sanitation for all [2]. This goal goes beyond water supply sanitation and hygiene (WASH) to include all aspects of the water cycle and explicitly recognize that water impacts the entire development agenda, it targets water quantity, quality, water use efficiency and water related ecosystems [3], [4]. SDG 6 aims to address the challenge of inadequate access of access to clean water and sanitation by promoting water conservation, the sustainable management of water resources, and the development of the efficient sanitation infrastructure by 2030 [5]. As highlighted in Table 1, SDG 6 has 8 targets which are designed to address a range of issues related to clean water and sanitation.

Table 1: *The main SDG 6 targets by the year of 2030 [2].*

6.1	By 2030, ensure global and equitable access to clean water for all.
6.2	By 2030, eliminate open defecation, emphasize on needs of girls, women and those in vulnerable situation, ensure safe access to sanitation and hygiene worldwide.
6.3	By 2030, enhance water quality, minimize dumping and limit the release of hazardous chemicals. Aim to reduce the share of untreated water to halve and sustainably increase recycling and reuse worldwide.
6.4	By 2030, increase the water use efficiency throughout all sectors, and guarantee sustainable extraction and distribution of freshwater, reduce water scarcity and people affected by it.
6.5	By 2030, ensure the application of integrated water resources across different levels, comprising of cross border partnership where appropriate.
6.6	By 2030, protect and rehabilitate ecosystems comprising of rivers, aquifers, lakes, mountains, forests, and wetlands.
6.a	Broaden global cooperations and capacity development by 2030, help developing countries in sanitation and water related processes and programs, comprising wastewater treatment, the use of recycling and reuse technologies, harvesting, desalination, and water efficiency.
6.b	Help and provide support to the local communities to strengthen their participation in improving water and sanitation management.

While progress toward SDG 6 is being monitored, a lot of limitations remain in ensuring equitable access to clean water and sanitation worldwide. The World Health Organization (WHO) reports that roughly 2.2 billion people, or one in four, still don't have access to safely managed drinking water at home, whereas 3.4 billion people, or two in five, do not have access to safely managed sanitation. More-over approximately 2 billion people don't have facilities to wash their hand at home [6]. The goal of SDG6 is to ensure clean water and sanitation availability for all by 2030, yet, the progress towards achieving SDG 6 should be paced up [2].

1.2 Importance of clean water and sanitation

Clean water and sanitation are indispensable for sustaining human life, driving economic growth, and preserving environmental health [7]. Availability of safely managed water and sanitation are one of the fundamental human rights, and, if lacking these services, people are more vulnerable to risk of fecal-oral pathogens and SARS-cov2 [8]. Clean water is essential for drinking, cooking and maintaining hygiene, preventing water borne diseases such as diarrhea and cholera, which continue to affect millions of people globally, there are 100000-120000 deaths due to cholera every year [9] Contaminated water in food production can introduce harmful pathogens into the food chain, highlighting the critical need for safe water in every stage of production [10]. Additionally, Lack of enough availability of clean water hinders the practices of health infrastructure and health staff [11].

Public health is intricately linked to water access, as poor sanitation and unsafe water sources contribute significantly to disease burdens worldwide, with basic hygiene practices like handwashing

proven to reduce Gastrointestinal illness by up to 50% [12]. Moreover, no access to clean water and proper sanitation increases the risk of diseases, The of level of access to clean water and proper sanitation determines the amount of illness reduction, however on average the level of reductions of diarrhea is 32% and 28% respectively for clean water and sanitation [13]. Children are more vulnerable to disease that arises due to insufficient sanitation, in India 57% of children that are under the age of 15 in sub urban areas and under the age of 10 years in urban areas practice open defecation [14].

In agriculture, water is the backbone of irrigation and livestock farming, accounting for nearly 70% of global freshwater withdrawals and playing a pivotal role in ensuring food security [15]. Similarly, industries depend on clean water for manufacturing, cooling and maintaining product quality, with sectors like food processing, textiles and pharmaceuticals relying heavily on uninterrupted water supply [16]–[18]. Additionally, clean water is vital for maintaining freshwater ecosystems, which support biodiversity, and provide essential services like water purification [19]. This shows that water and sanitation are an important part of the SDGs, and its progress should be tracked continuously and managed properly to ensure equitable clean water and sanitation access to all by 2030.

Figure 1 illustrates the disparities in access to clean water and sanitation across different regions of the world. North America, Europe and Central Asia show the highest levels of access, with over 90% of their populations having access to clean water and relatively high access to sanitation services. In contrast, regions like Sub-Saharan Africa and South Asia face significant challenges, with much lower percentages of their populations having access to these basic services. Sub-Saharan Africa, in particular, lags far behind, with only 32% of the population having access to clean water and 25.6% to sanitation. While some regions, such as East Asia and Pacific, have made progress in providing clean water, access to sanitation services remains considerably lower. The global averages reflect this imbalance, with around 72.9% of the population having access to clean water, but only 56.6% having access to adequate sanitation. This data highlights the need for increased efforts to address regional disparities and improve access to water and sanitation services, especially in areas where infrastructure development has lagged population growth [20].

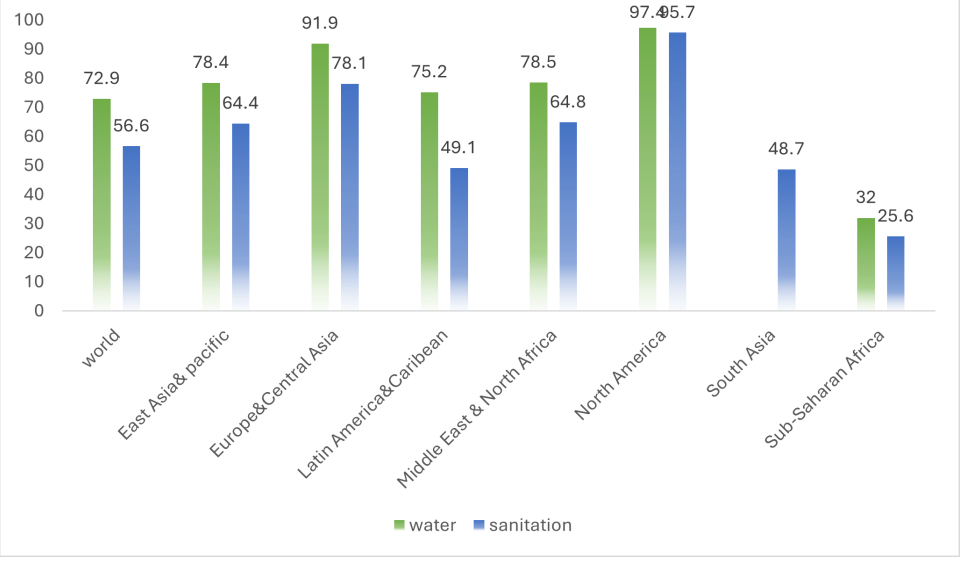

Figure 1: *Access to clean water and sanitation by region (% of population) .*

1.3 Challenges to achieving SDG 6

Based on literature, there are numerous challenges on the way to implement SDG 6. Among those, one of the primary challenges in reaching this goal is the inadequate infrastructure for providing clean water and sanitation in many regions. In some areas, there is a lack of sufficient clean drinking water sources and limited access to proper sanitation facilities, which contributes to continued practices such as open defecation [21], [22] . For instance, 419 million still defecate in the open, for example in street gutters, behind bushes or into open bodies of water [23].

Moreover, climate change further exacerbates the challenges of managing water resources. Lack of safe drinking water is a significant problem due to climate change [24].The increasing number and severity of storms, floods, and droughts are worsening water scarcity in many regions [25]. As surface water resources are reducing, dependance on underground aquifers increases, which leads to the reduction of groundwater levels [26], [27]. Extreme weather events, such as unusually heavy rainfall, can overload both natural and human made storage systems, leading to put further pressure on water supplies [28], [29].

In addition to environmental challenges posed by climate change, urbanization has disrupted the balance between ecosystem services (ES) and sustainable water resources management. The Accelerated urban growth has led to increased demand for water, hence causing pollution, and the encroachment of water bodies, particularly in peri-urban areas [30], [31]. Wastewater is released to the peri-urban areas, which reduces the surface-water quality of the area. The most common water-related challenges facing peri-urban residents include water pollution, increased demand and encroachment of water bodies [32]. The wastewater that is percolated picks a lot of heavy metals with itself and reach to underground, hence reducing the quality of ground water and contaminate groundwater [33].

Alongside challenges like urbanization that strain water resources, another critical barrier to achieving SDG 6 is the limited public awareness regarding the SDGs and the 2030 Agenda. Despite efforts at all levels, community-level awareness remains low [34]. Raising stakeholder awareness is also important , as good understanding of the SDGs can encourage behaviors that support sustainability and the realization of these goals [35]. A significant barrier to achieving SDG 6 is the economic limitations. Many regions face in building and maintaining water and sanitation infrastructure. Financial constraints limit investment in essential facilities, resulting in inadequate water systems and insufficient sanitation coverage, particularly in lower-income areas. Emerging economies in particular pace significant issues to implement SDGs effectively, some countries relied on business to achieve these targets [36].

Overcoming these challenges is vital for achieving SDG 6. Progress will require coordinated efforts to improve infrastructure, increase climate resilience, promote sustainable urban planning, and raise awareness. Partnerships among private sectors and local communities are essential to develop adaptable, region-specific solutions. Without urgent action, the combined pressures of climate change, urbanization, and financial limitations will continue to hinder global efforts, underscoring the need for inclusive and sustainable strategies to meet SDG 6 by 2030.

1.4 Objectives

The objective of this research is formed in different goals including (i) examine the key challenges that are hindering the progress toward achieving the SDG 6, and (ii) analyze the aspects that are continuously impeding access to clean water and sanitation worldwide. This review focuses on different critical areas insufficient infrastructure, the impact of climate change to achieving SDG 6, the effects of urbanization and the low quality of water as a result of urbanization, the role of public awareness in supporting sustainable water management practices and the importance of funds available to accelerate the progress towards achieving SDG 6, by identifying these major gaps, the aim of this review is to present a comprehensive understanding of the ongoing barriers to SDG 6

and highlights the area where actions are most urgently needed to accelerate the progress toward universal and equitable access of clean water and sanitation for all.

1.5 Survey process

The survey process begins with a thorough literature review to establish the foundation of our study. Following the review, we identify key factors influencing SDG 6 which are clean water access, climate change, urbanization, public awareness, and financial mechanisms. Each factor is scrutinized for its impact and interrelation with the clean water resources' availability and sustainability. The discussion section synthesizes findings from the analysis of these factors, providing a comprehensive overview of the challenges faced. The process culminates with a conclusion that encapsulates the insights gathered throughout the survey and suggests potential pathways for achieving SDG 6 (Figure 2).

Figure 2: *Flow diagram of the challenges to achieving SDG 6.*

The literature reviewed in this paper was sourced using google scholar as the database, keywords were selected in a way to identify relevant studies to the challenges and strategies for achieving SDG 6. These include "SDG 6", "Clean water and sanitation", "water scarcity", climate change and water resources", "public awareness for sustainable water management", "economic barriers to SDG 6 implementation", "Integrated water resources management (IWRM)", "Urbanization and water resources", and "innovative financing mechanisms for water infrastructure".

Key themes that emerged from literature include: (i) the impact of climate change, urbanization, financial barriers, and public awareness on water and sanitation access. (ii) Technology innovations such as smart water systems, governance improvements. And community engagements. (iii) the link between water access, public health, economic development, and environmental sustainability.

2. Literautre Review

2.1 Clean water access

The United Nations adopted a set of SDGs to build upon the foundation laid by Millennium Development Goals (MDGs) [1]. SDG 6 devoted to cleaning Water and sanitation, Its goal is to ensure the availability and sustainable management of water and sanitation for all and achieving quality and sustainability of water. Goal 6 is about equitable access to clean water and sanitation worldwide. However clean water and sanitation have specific definitions according to Joint Monitoring Program (JMP), the Custodian of global WASH. JMP categorizes drinking water as safely managed, basic, limited, unimproved and surface drinking water, here we adopted the JMP definitions for drinking water, Improved drinking water sources are those that are designed and constructed to provide clean water. The JMP categorizes households accessing improved services at three levels based on their access. For a household to have access to safely managed drinking water, the water source must be accessible on the premises, available whenever needed, and free from contamination. If an improved source does not meet any of these criteria, but water can be collected from a source with a round trip of 30 minutes or less, it is categorized as basic drinking water service, it water collection from an improved source takes more than 30 minutes it is categorized as limited drinking water service, the JMP also identifies households using unimproved sources, like unprotected wells, and those relying on surface water such as river, lake, dams, stream [37].

While ensuring access to clean water is an important aspect of SDG 6, it is equally important to realize that access to sanitation plays a critical role in achieving the overarching goals of this sustainable development objective. Access to clean water and sanitation does not mean that SDG 6 has been achieved, access to sanitation is another aspect of the SDG 6 which is as important as access to clean water and sanitation. According to JMP there are different definitions of sanitation, based on which the progress to achieving sanitation is measured. Sanitations services are the management of human waste and transporting them from human facilities for treating, discharging and reuse. Sanitation has been categorized as safely managed sanitation, basic sanitation, limited sanitation. unimproved sanitation and open defecation. To meet the standards for safely managed sanitation, three conditions must be satisfied: households should have enhanced facilities that are not used by others, human waste produced should be treated or disposed of in designated locations, and waste must be temporarily stored before being emptied and treated off-site or transported via a sewer system. If waste from improved sanitations facilities is not safely treated or discharged, individuals using those facilities are categorized as having access to basic sanitation. Households using enhanced facilities that are used by others too, are categorized as having access to limited sanitation services [38].While keeping in mind the definitions of drinking water and sanitation and measuring the progress towards the SDG6, there is still a lot of hard work to be done. Globally, 2 billion people still do not have access to safely managed drinking water services [39].The global variations in access to clean drinking water are illustrated in Figure 3, highlighting the percentage of populations with access to safely managed drinking water across different regions [40].

According to WHO, in 2022, 57% of the global population (4.6 billion people) used a safely managed sanitation service. People that are still without access basic sanitation is 1.5 million, of these 419 million people defecates in the open areas [41]. The differences in access to safely managed sanitation services are depicted in Figure 4, showing the percentage of people with access to improved sanitation facilities worldwide [42].

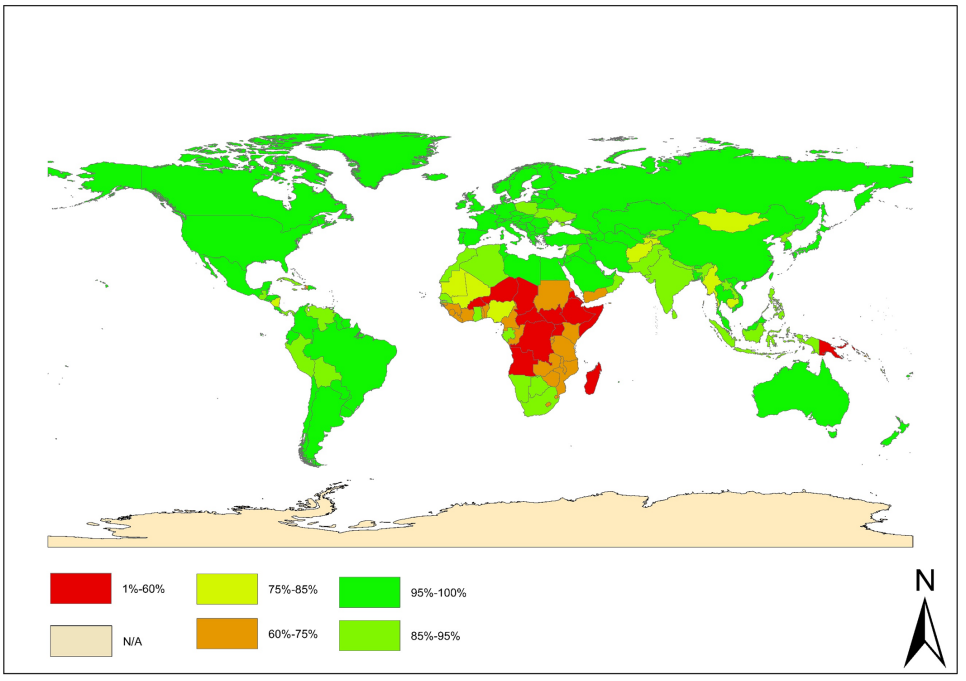

Figure 3: *Population with Access to Basic Drinking water by Country (Percentage).*

Focusing on specific regions, in Ethiopia, 49.6% of people have access to improved drinking water, and only 6.3% have access to improved sanitation [13]. There are significant disparities of access to clean water and sanitation between urban and rural areas. For example In the Solomon Islands, 92% of urban population have access to at least basic drinking water compared to only 55% in rural areas [43]. Similarly in Zimbabwe 98% of the urban residents have access to clean water, while only 57% of the rural do, highlighting a significant Gap between urban and rural households [44]. Figure 5 illustrates the disparities in urban and rural access to clean water in Zimbabwe and Solomon Islands, highlighting the gaps in both access and no access percentages.

Moreover access to sanitation in urban areas compared to rural areas also reveals significant divide, Over 69% of rural households in India do not have improved latrine facilities within their premises, this proportions is 19% for urban households [45]. These disparities can be reduced by effective operation and maintenance OM of rural water supply and sanitation systems, Effective OM ensures the long term functionality of water infrastructure, particularly in rural areas where resources are scarce and access is limited [46]. Furthermore conflicts in certain regions exacerbated these challenges in some areas, for example, in Syria, in 2010, more than 90% of the population had access to improved drinking water but now, due the ongoing conflict around12 millions Syrians needs access to WASH services [47]. A significant proportion of people that do not have access to clean water and sanitation, live in low and middle income countries, 319 million in sub Saharan Africa, 134 million in south Asia, 61 million in southeast Asia, and 65 million lives in East Asia [48].

Beyond regional disparities, access to clean water is further constrained by inadequate infrastructure and the need for households to travel long distances to reach water sources. This is contradicting with the definition of JMP, which states that water collection from an improved source should not exceed more than 30 minutes, approximately one in ten people don't have clean water close to home [49] .in shahibug slum in Bangladesh, 70% of the people do not have access to clean water due less

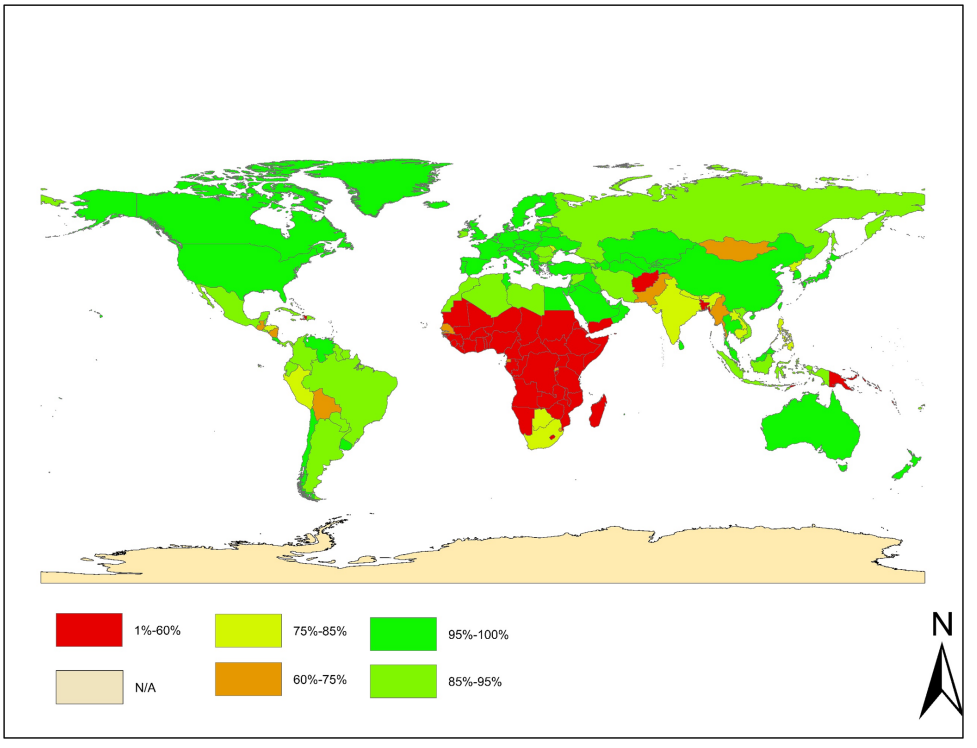

Figure 4: *Population with Access to Basic Sanitation Services by Country (Percentage).*

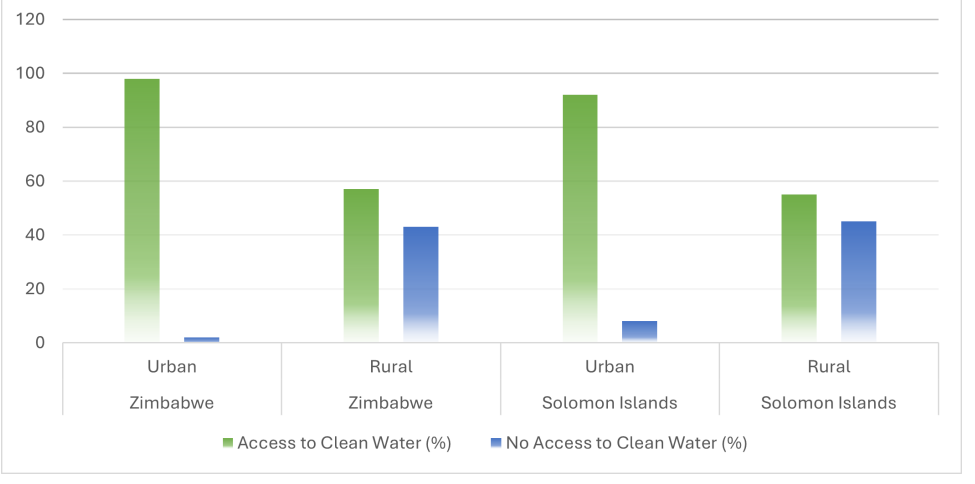

Figure 5: *Urban and Rural access to clean water in Zimbabwe and Solomon Islands.*

number of water source points [21]. Additionally, responsibilities such as job, cooking and going to school could affect households' ability to wait and queue for water, this may lead people to use easily accessible sources that are of lower quality. Access to limited source points have an impact on the coping cost of clean water access. People often travel and get access to paid clean water access which leads to excess cost to afford clean water, in India the coping costs for high income households

are 1% and of their income, while for low income households, the coping costs rise to 15% [50]. looking at the growing demand, it is predicted that in developing countries the demand will surpass its supply by 30% [51].

2.2 Impacts of Climate Change

Climate change is one of the bigger global challenges, with profound implications for natural resources, ecosystems, and human livelihoods. The impacts of Climate change as summarized in Figure 6, are Divers and far reaching, Among these ,Climate change related hazards and water Scarcity poses a significant risk to WASH services [52]. Defined as the increase in average global temperature since the industrial revolution [25]. Climate change has a twisted link with water resources. Recent global water stress and scarcity indicate that climate change presents a higher risk to water resources than previously thought, significantly impacting the water cycle and putting sustainability of water resources at risk[53]. Moreover the intensification of droughts in arid and semi-arid regions coupled with the growing population increased water demands [54].

The exacerbation drought condition significantly enhanced water scarcity, hence impacting arid and semi-arid regions worldwide [55]. Climate change is the main driver of water scarcity, which is defined as areas where annual water supply is less than 1700m3/year per capita [26]. Furthermore, the implications of climate change extend beyond water availability, significantly affecting water quality and sanitation services, thereby challenging efforts to meet global sustainability goals. Climate is an anthropogenic activity that challenges our ability to maintain the sustainability of water resources [56]. It interrupts the hydrologic cycle which leads to a change and redistribution of water resources worldwide [57]. Moreover, climate change causes significant change in freshwater quality due to chemical changes, increased nutrient concentrations, and changes in the color of the water [58].

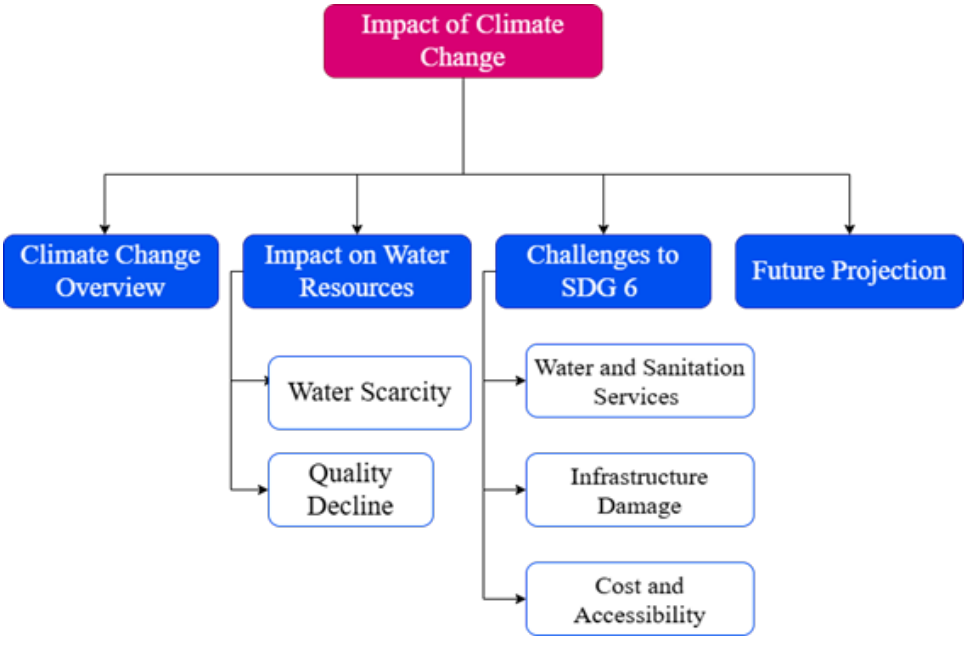

Figure 6: *Impact of Climate change on Water Resources and Challenges to SDG 6.*

The rise in temperature due to climate change is expected to raise the demand for water in the coming years [59]. Given these multifaceted impacts of climate change, progress toward achieving

SDG 6 is significantly hindered and impeded. Consequently, a decrease in water availability due to these impacts intensifies the pressure on groundwater resources, further exacerbating the inaccessibility to freshwater. This strain is evident in increase water stress which is an indicator of the pressure on an area's water resources as the total freshwater withdrawal to total renewable freshwater available, a lower ratio means that freshwater usage is sustainable [60].

Climate change poses a significant obstacle to achieving SDG6, with the projected changes affecting water and sanitation services across the world, this contains that changes in water quality and presence of contaminations in water supplies [61]. Additionally, climate change can significantly affect existing sanitation systems, and slows down the progress towards achieving the SDG6 target by variations in water cycle [62]. The increase in intensity and frequency of droughts, rising sea levels, heavy rainfalls, and severe storms are the impacts of climate change that threaten to destroy sanitation systems, disrupt services, and render access to safely managed sanitation more expensive and slow to achieve globally, for example in Botswana, droughts led to residents stop using flush toilets connected to sewer systems due to water restrictions [63].

Beyond droughts and water stress, climate change affects the accessibility of water by damaging reservoirs and infrastructure. In South Africa an intense thunderstorm destroyed boreholes that were supplying water to prince albert and damages the nearby infrastructure and water reservoirs [64], [65]. Over the past decades the availability of water per capita has been declining [66]. And it could get worse due to the anthropogenic activities that are still the main drivers of climate change. Water availability is of significant concern in areas already suffering from lower water resources levels, leading to increased drought and water scarcity, thus increasing the gap between water demand and supply [67]. While groundwater is one of the main sources for providing fresh water, particularly in arid regions, due to climate change and the scarcity of water, the sustainability of these groundwater sources is threatened [68]. Therefore, posing a significant threat to access clean water. One of the impacts of climate change is rising sea levels due to which the surface and ground waters salinity rises up and further damages the already Scarce freshwater resources [25], [69].

Moreover between 2020 and 2025, global water demand is expected to increase by 55% [69]. Which highlights the need to address the current inaccessibility of clean water and sanitation, without instant action the impacts of climate change could exacerbate even more and intensify water crisis, sanitation services and thus slow down the progress towards achieving SDG6.

2.3 Urbanization

Defined as a process of people moving from rural area to cities. Urbanization results in the expansion of the urban areas often driven by economic opportunities and better services. Approximately 55% of the total world population were living in urban cities in 2018 and this is projected to raise to 68% by 2050 with the urban population increasing by 22000 per day [70]. However, the rapid growth of urban cities poses a risk to achieving sustainable development goals [71], especially SDG 6. Impervious surfaces increase due to new development in urban areas, that reduces the groundwater recharge, these factors lead to inaccessibility and reduction of clean water resources [72]. Furthermore as the urban population increases, the supply for clean water and proper sanitation must also be increased to match the rate of urbanization, for example in China the percentage of urban population in 2030 will be 70.6% which brings in new difficulties with itself for providing sustainable public services [73]. In many developing countries, the rate of urbanization is significantly faster than the development of clean water and sanitation services. This discrepancy results in increasing pressure exerted on the public infrastructure in these regions [74]. The accelerated expansion of urban areas without corresponding development of the basic sanitation services has a substantial impact on environmental degradation, for example Bandung city in Indonesia experiences high rate of Urbanization that is not matched by enough development of sanitation services, facing many problems to supply basic sanitation [75]. In addition, increased rate of urbanization not met with proper sanitation services

will pose a great risk to environmental conditions, in most urban cities there is no central treatment facility for sewage or even don't have sewers system [76]. Thus, most of the houses use on-site sanitation services including septic tanks, bucket latrines. The fecal waste collected from these places are directly thrown into urban rivers, and streams, which turns rivers and water bodies into open sewers, thus poses high risk to water resource [77].

While rapid urbanization places significant pressure on water supply and sanitation services, the increasing levels of pollution further exacerbate the stress on water availability, for example 70% of the overall available water are polluted in India due to waster from human activities which are disposed directly to the environment without treatment [78]. Such surface water resources then percolate to the aquifers and hence contaminate the groundwater water [33].This insufficient water quality can lead to scarcity of water, in Bangladesh 35 million habitats were susceptible to arsenic due to the contamination of groundwater [79]. Furthermore urban runoff contributes to non-point source pollution, which poses a significant risk to water quality, according to US Environmental Protection Agency, non-point pollution is responsible for the pollution of 40% of the water bodies in the US [80]. Around quarter of world population lives in urban slums [81]. Living in unfit habitation and shelters, urban slums are more vulnerable to unsafe drinking water and sanitation due insufficient and inappropriate drinking water and sanitation services [82].

The generation of urban waste, which decreases water quality, and inadequate sanitation services due to rapid urbanization are not the only challenges posed by urban growth. Another major threat is the reduced groundwater recharge caused by urbanization, as it expands, the land use of the urban area changes and hence resulting in the shortage of the impervious lands, which cause floods, droughts and less rainwater infiltration. For instance, in Delhi, India during 2011 and 2013 however the rainfall was increased during those years but the recharge rate due to rainfall consistently decreased due to increased urbanization [72]. Also, as more areas in urban cities become impervious due to sidewalks, roads, and buildings, the quality of stream waters also deteriorates because of the pollution that is carried out due to increased run-off from urban impervious areas. A study conducted in Washington, US, says that even with a small amount of surface imperviousness of 10%, there occurs significant degradation in streams [80].

2.4 Public awareness

Public awareness and education are instrumental in achieving SDG 6, rising awareness about water pollution, clean water access and safe sanitation practices can encourage the public to change their lifestyles that support clean water access and sanitation. Education of the public is important to have a deeper understanding of water scarcity and sanitation. It is an important area of focus to reduce the gap between public policy and community actions. According to recent reports public awareness and understanding of the public seems to be too low, even though some actions have been taken [34]. A study conducted in Australia through an online survey and semi-structured interview shows that the understanding level of SDGs is low even between those who pretend to be aware of them [83]. In order to achieve SDGs, particularly SDG 6, most of the population must know about the importance of these goals and apply these goals in their personal life, in another survey that was conducted across 9 Italian universities, asking through questionnaire, 1676 questionnaires were completed from which 92.4% students had a low-level understanding of the SDGs, while only 7.6% had a high-level understanding [84]. Likewise Awareness regarding the SDG 6 is also missing, A survey conducted in Spain, shows that the public knows the importance of water and is aware of the need to improve water efficiencies, and even think that climate change is a factor that might affect water use, however a lot of the public population claim that they are not aware of the SDG 6 [85]. Hygiene and sanitation education (HSE) programs are important to improve understanding of the link between hygiene, water, sanitation, and health, especially in rural communities. This include teacher training, workshops and distribution of educational materials [86]. One of the main

contributors are research along educational institutes in raising education and awareness among students [87]. Radio and TV programs and Presentations on SDGs and their importance can play a vital role in rising the social awareness level [88]. While public awareness of the importance of SDG 6 is generally low, particularly concerning its implications for clean water services, the level of education significantly influences both understanding and willingness to invest in these essential services. In most cases families that use clean water and improved sanitation systems are the one with high educations and awareness [30]. In contrast in some cases it is shown that the SDGs that have a direct impact on people's lives or affecting them daily, have a higher awareness among the publics [89]. In some cases the households are not willing to pay for the clean water services and services provided by the government, however in a study by [90], It is perceived that if publics are aware about the use of water and the risks that are linked with improper sanitation and hygiene services and polluted water, the desire to pay for the services is increased. Similarly, enhancing public awareness and understanding of SDGs is crucial for fostering collaboration and motivating individuals to actively engage in sustainable development initiatives. It is realized that citizens in throughout all the countries must be Deployed to involve with sustainable development . It is important to assess public perceptions and know their formation in order to promote public participation in SDG actions [91]. For the people to contribute to achieving the SDGs, they must be aware of these Goals and work in Collaboration to achieve them. Without having an understanding and awareness of these goals, SDGs are in risk of remaining as another set of unachieved goals [92].

2.5 Economic barriers

The financial investment needed for SDGs were first evaluated in UCTAD's report in 2014 [93]. Achieving SDG 6, which focuses on clean water and sanitation, requires a great amount of financial investment, but many countries particularly developing countries face significant challenges in providing financial investment, that slows down the progress towards achieving the goal. In light of these challenges, specific investment figures highlight the severity of the funding gap. According the UNCTAD, to meet the SDGs by 2030, the annual total investments in developing countries should be between 3.3 trillion dollar and 4.5 trillion dollar, which shows that there is an annual gap of 2.5 trillion dollar between current funding and the funding required [94]. Corona virus pandemic has exacerbated the situation and increased the Gap for the financial investment [95]. The gap is widened from 2.5 dollar trillion in 2015 to 4 dollar trillion in 2023 with the largest changes were in energy water and transportation sectors [96]. Furthermore, the world bank estimates achieving the target of clean water and sanitation will cost roughly US 114 billion dollar per year from now until 2030, and these are the cost to just build the infrastructures, not including the maintenance costs over time. However the official Development assistance (ODA) is short of what is needed, that indicates the need for private investment [97]. to bridge this significant gap, blended finance represents a promising solution, this solution combines the financial resources from various sectors, philanthropic and private sector [98]. Moreover introducing central bank mandates for sustainable development and increasing the strictness of polices of multilateral development banks are some of the solutions in reducing the gap [99].

3. Integrating Solutions and Strategies

Achieving SDG 6 demands a diverse and comprehensive approach that handles the challenges of limited access to water, climate change, urbanization, economic barrier and public awareness to ensure the availability of clean water and sanitation for all. One main solution is climate resilient water and sanitation infrastructure [100], especially in regions that are more vulnerable to climate change impacts. It encompasses building systems that are durable against extreme weather events like droughts, floods and rising sea levels [101], which have increasingly threatened water availability and quality. For instance, fortifying water storage and distribution networks can help secure

supply during droughts, while constructing flood-resistant sanitation facilities can ensure that services remain functional during periods of heavy rainfall [102]. Moreover, prioritizing the rural water systems and facilitating lasting financial structures and institutional support, resulting in the sustainability of rural water supply infrastructure for their intended life, and a long lasing service needs to be established [103]. is essential to narrow the disparities in access between urban and rural areas. In urban areas, adopting nature-based solutions such as green infrastructure, and the use of constructed wetlands can enhance water quality [104]. Such strategies not only alleviate the pressure on existing water resources but also improve urban resilience against the adverse effects of rapid growth and development. Likewise, climate-responsive water management practices, such as integrated water resources management (IWRM), play a critical role in promoting efficient use and equitable distribution of water resources [105]. These practices facilitate the coordination of policies and strategies across sectors and stakeholders, enabling countries to adapt to changing supply patterns and mitigate water scarcity [106]. Simultaneously, strengthening regulatory frameworks and enforcement mechanisms is vital to reduce water pollution caused by untreated waste, industrial effluent, and agricultural runoff. By implementing stricter water quality standards and enhancing the monitoring of water sources, governments can address contamination issues that undermine access to safe drinking water and sanitation.

Addressing the significant financial barriers to achieving SDG 6 requires innovative approaches to funding. Blended finance models, which combine public, private, and philanthropic investments offer a promising way to close the funding gap [107]. These models can attract private capital to water and sanitation projects that might otherwise be underfunded, particularly in low-income countries. Additionally, partnering with multilateral development banks can secure the necessary resources for critical infrastructure projects, including those aimed at expanding access to safely managed drinking water and sanitation services [108]. Expanding the role of central banks and encouraging sustainable investment mandates could further direct funding toward achieving water and sanitation goals, while reducing reliance on traditional sources of ODA.

Enhancing public awareness is another crucial pillar in this effort, as it directly impacts community engagement and behavior change [109]. Education programs, community outreach initiatives, and media campaigns can raise awareness of the importance of clean water access, safe sanitation, and the broader goals of SDG 6. Such programs should emphasize the risks associated with poor water quality and inadequate sanitation and promote water-saving practices and hygienic behaviors. Moreover, fostering local participation in water management decisions can help communities feel more responsible for the maintenance of local water systems, leading to better stewardship of water resources. As awareness grows, so does the willingness of individuals and communities to invest in water and sanitation services, thereby contributing to the financial sustainability of these initiatives.

In addition, leveraging technological innovations is pivotal for optimizing water resource management and improving access in underserved regions. The deployment of smart water management systems, including smart water meters and remote sensing technologies can help monitor water usage, detect leaks, and ensure efficient distribution [110], [111]. Low-cost water purification technologies, such as solar desalination and filtration systems, offer accessible solutions for communities facing water quality challenges. Emphasizing innovation can also bridge the gap in service delivery between urban and rural areas, making it easier to reach isolated populations with limited access to clean water and sanitation [112].

By integrating these strategies, countries can address the diverse and complex challenges that have impeded progress toward SDG 6. This holistic approach ensures that climate adaptation, infrastructural development, financial investment, and public engagement work together to promote sustainable access to clean water and sanitation. These efforts are vital not only for improving health and well-being but also for fostering economic development, social equity, and environmental sustainability. Through coordinated action, the world can advance toward the realization of SDG 6,

ensuring that clean water and sanitation are accessible to all, regardless of geographical or economic barriers.

4. Importance of urgent action to achieve SDG 6

Immediate action to achieve SDG 6 is important for several reasons: (i) Access to clean water and sanitation is crucial for human health and human rights, but still billions of people worldwide face difficulties accessing these services. (ii) climate is exacerbating the challenges related to water resources, especially for vulnerable communities, showing the urgency of proactive measures to mitigate its efforts. (iii) Sustainable water and sanitation management is important to achievement of other SDGs, including those focused on health, education, and economic development.

Addressing the ongoing global issues of water and sanitation access is crucial to realizing SDG 6. Despite developments, more than 2 billion people do not have access to safely managed drinking water, and 3.4 billion lack access to safely managed sanitation services [6]. Without immediate intervention the impacts of these lack of water and sanitation services will continue to be severe, with millions of people facing risks of waterborne diseases such as cholera and diarrhea [9], [113]. These preventable diseases disproportionately affect vulnerable populations, specifically children in low-income countries, contributing to high mortality rates and hindering socioeconomic development.

Not taking action poses significant economic consequences, water scarcity is estimated to cost global economies hundreds of millions of dollars yearly, reducing productivity, industry, and other water dependent sectors [114]. Moreover, delayed progress toward SDG 6 threaten environmental sustainability, as unsustainable practices and pollution continue to degrade freshwater ecosystems [115]. Rising global temperatures and climate change related disasters, such as floods and droughts, are intensifying these challenges, further exacerbating water scarcity and infrastructure damage.

Worldwide collaboration is essential to bridge these gaps, the Global Water Partnership (GWP) emphasize the importance of integrated water resource management [116]. Financial mechanisms, including the World Bank's Water Global Practice and blended financing models, aims to bridge funding gaps [117]. Technological advancements, such as smart water systems, and water recycling, are deployed to optimize resource management. Additionally, UNESCO's Water for Sustainable Development program emphasize on capacity building and governance to enhance water sustainability globally [118]. Policy makers must prioritize urgent measures such as climate-adaptive water systems, innovative financing models, and technology driven solutions to ensure equitable water access. Community participation in water management and public awareness campaigns are equally important to fostering sustainable practices at the grassroots level. Immediate, and coordinated action is the only way to overcome existing barriers and realize the vision of clean water and sanitation for all by 2030.

5. Summary of key challenges

The pursuit of SDG 6 faces numerous interconnected challenges as illustrated in Figure 7, each impeding global access to clean water and sanitation. A critical issue is limited clean water access, especially in rural and low-income urban areas, where disparities with urban centers leave millions without access to safely managed water and sanitation services. Infrastructure limitations exacerbate these disparities, as aging or insufficient systems fail to meet the needs of rapidly growing populations, leading to high coping costs for affected communities. For instance, many households in under-resourced areas must resort to expensive and time-consuming methods to obtain potable water.

Climate change also poses a significant barrier, raising temperatures, changing precipitation patterns, and increase in extreme weather events and water scarcity, this puts pressure on already scarce water resources. These climatic changes also contribute to water quality being decreased, with increased runoff and pollution harming freshwater ecosystems and reducing the availability of safe drinking water. Climate change also physically damage water infrastructure, specifically

in vulnerable regions, hence reducing the reliability of water access and sanitation services. The increase in water demand, driven by both population growth and higher temperatures, intensifies the pressure on limited resources, making it harder to provide equitable access to water.

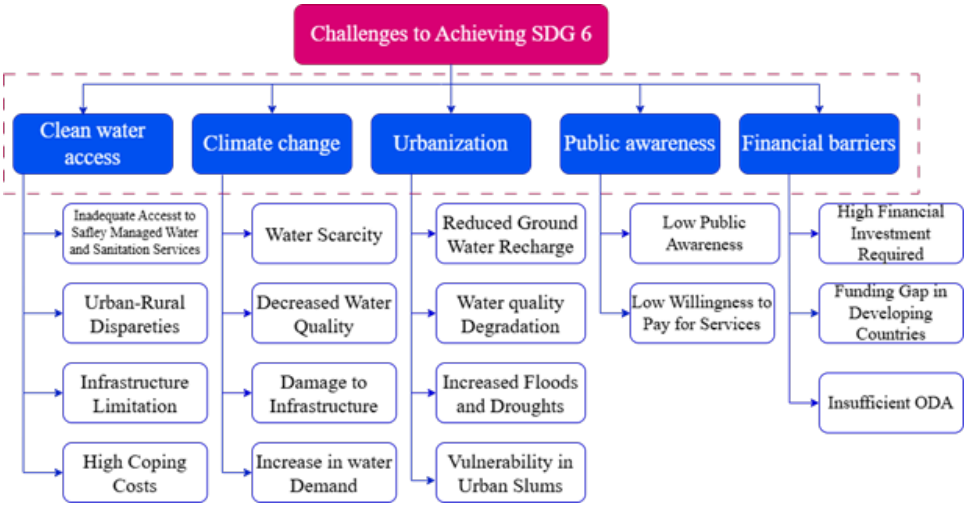

Figure 7: *Summary of challenges discussed in this survey.*

Urbanization further complicates these issues. Rapid urban growth, often unplanned, reduces groundwater recharge as natural landscapes are replaced by impermeable surfaces like roads and buildings, which prevent water from seeping back into the ground. This urban expansion also contributes to significant water quality degradation, as inadequate wastewater treatment systems release untreated or partially treated wastewater into water bodies. Flooding and droughts are becoming more frequent in urban areas, stressing sanitation systems and increasing health risks for residents, particularly those in urban slums where vulnerabilities are most acute. These slum areas often lack essential infrastructure, making them highly susceptible to waterborne diseases and other health hazards linked to poor water quality.

Public awareness is also a critical factor. Low levels of public understanding about sustainable water and sanitation practices hinder efforts to engage communities in behaviors that support SDG 6. Furthermore, there is a lack of willingness to pay for water services in some areas, which limits funding options for service improvements. This reluctance may stem from limited knowledge about the long-term benefits of safe water and sanitation or from distrust in service providers. Without widespread public support and participation, initiatives to improve water quality and access face significant setbacks, as communities may not adopt or sustain needed changes.

Lastly, financial barriers pose one of the most formidable challenges. The high financial investment required to build and maintain water and sanitation infrastructure is often beyond the capacity of low-income countries, leading to a persistent funding gap that slows progress toward SDG 6. Developing countries, in particular, struggle to mobilize resources for necessary investments, and this is exacerbated by insufficient ODA from wealthier nations. The lack of consistent and substantial funding means that many regions cannot adequately address their water and sanitation needs, leaving millions without essential services.

Together, these challenges highlight the need for coordinated, multi-level action to overcome both existing structural issues and the additional pressures brought on by climate change, urban growth, and financial constraints. Addressing SDG 6 will require a blend of innovative infrastructure

solutions, climate resilience measures, community engagement initiatives, and sustainable funding mechanisms to bridge these gaps and build a more equitable future for water and sanitation access.

6. Call for action: Policymakers and stakeholders

Immediate action is essential for policy makers and all the stakeholders to achieve SDG 6. Key players, including private sectors, NGOs and civil society, perform a crucial role in promoting progress, private companies participating through public-private partnerships that lead to financial resources, technological innovation, and expertise to water and sanitation projects. NGOs should focus on raising public awareness and encourage a culture for sustainable water use and enhance the engagement of communities. Communities with knowledge about SDG6 can drive sustainable water practices, turning them into key contributors in achieving the SDG6.

Policy makers must prioritize water and sanitation infrastructure by implementing policies that support sustainable water management and encourage the efficient allocation of resources. Policies address the urgent impacts of climate change, which threaten water availability and quality. Policy makers must focus on nature-based solutions that minimize the environmental impact and improve water quality and security. Urban planners should integrate sustainable water management practices to handle the challenges posed by urbanization.

International organizations must focus on improving financial support, and funding water and sanitation projects should be on top of the list. International financial support and enhanced financial mechanism is the key to reducing the gap the hinders the progress towards SDG 6. Achieving SDG 6 requires a unified effort across sectors and at every level. By committing immediate action and fostering cross-sector collaboration, policymakers and stakeholders can overcome the current barriers to clean water and sanitation, ensuring that the right to safe water becomes a reality for all.

7. Conclusion

The achievement of SDG 6 remains a major issue and a serious challenge. As mentioned in this paper, obstacles to global access of clean water and sanitation are numerous, including, unequal access to clean water and sanitation, the worsening impacts of climate change, rapid growth of Urbanization, limited public awareness about SDGs, and funding challenges. Each of these barriers poses a different challenge and thus should be addressed through coordination and multi-level strategies. For example, while urbanization put pressure on water resources by increasing the demand and increasing pollution, particularly in urban slums where water and sanitation services are already inadequate, climate change exacerbates water Scarcity, damage water and sanitation infrastructures. Additionally, the level of public awareness and limited desire to take part in and support sustainable water management initiatives prevents the progress of SDG 6, financial barriers particularly in developing countries, complicate the situation even more as insufficient funds limit the ability enhance progress towards SDG 6.

The findings in this paper emphasize that different challenges in achieving this goal require an approach that incorporates climate resilient measure, public engagement, infrastructural improvement and enhanced funding mechanism that reduce the gap between available and required resources, in developing countries where progress towards SDG 6 is slower, would benefit from these targeted efforts to overcome these obstacles and progress towards achieving SGD 6 by global partnership and implementing coordinate solutions. Achievement of SDG 6 is not only important for human health, but also an integral part of achieving other SDGs, for example water Scarcity slows down the economic growth, environmental sustainability and underpins social equity. Immediate actions needed from civil society, government and private sector to achieve the ambitious target of SDG 6.

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