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Drinking Water Quality and Quantity: Challenges to Ensuring Sustainable Development

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RESUMEN

El crecimiento de la población humana, el tipo de sociedad y su organización, la energía y las materias primas requeridas por las sociedades modernas, presionan el futuro del abastecimiento de agua para la población, tanto en cantidad como en calidad. Simultáneamente, la migración humana a las áreas urbanas exige que las instituciones públicas encuentren suficiente agua con la calidad adecuada para satisfacer las necesidades de las grandes ciudades. En este contexto, esta investigación tiene como objetivo examinar los factores que pueden afectar el acceso futuro al agua, tanto en términos de cantidad (disponibilidad de agua) como en calidad, con el fin de contribuir a una política de desarrollo sostenible basada en principios de responsabilidad social.

ABSTRACT

The growth of the human population, the type of society, its organization, as well as the energy and raw materials required by modern societies, exert significant pressure on the future availability and quality of water supply for the population. Simultaneously, the migration of people to urban areas presents a challenge for public institutions to secure an adequate supply of water with the required quality to meet the demands of large cities. Consequently, this research aims to examine the factors that may potentially impact future access to water, considering both quantity (water availability) and quality, with the objective of contributing to the development and implementation of a Sustainable Development Policy (SDP) based on principles of social responsibility (SRP).

1. INTRODUCTION

Water is a crucial natural resource for the survival of species and for maintaining the equilibrium of ecosystems. Although the Earth is a planet full of water, only 2.5% of it is freshwater. Nowadays, there is a great concern about the capacity of existing freshwater resources to sustain life and human health. The concern for the quantity of water available is not greater than the concern for its quality. Water in nature has a wide variety of dissolved substances, some of which are harmful to human health and the equilibrium of ecosystems (UN, 2018b).

Apart from natural and human-induced factors that influence water quality, climate change can also significantly affect both the quantity and quality of water bodies. The temperature and extreme weather events caused by climate change play a critical role in this. The rise in temperature affects chemical equilibrium and the speed of biochemical reactions in water, leading to various phenomena such as dissolution, solubilization, complexation, degradation, or evaporation of chemical solutes. This results in an increase in the concentration of chemical solutes in water and a decrease in the concentration of gases. Moreover, an increase in radiation due to climate change leads to photochemical phenomena that alter water quality, particularly concerning organic compounds dissolved in surface waters and micro-pollutants originating from anthropogenic activities. It is crucial to address the impacts of climate change on water quality and take necessary actions to mitigate them (Konapala et al., 2020).

Water transport pollutants to downstream areas, impacting the quality of the receiving water and surrounding soil. To prevent these pollution phenomena, it is essential to understand the activities that generate pollution and the specific types of pollution they contribute to. Roads and highways, for instance, cause pollution in various ways, affecting the soil and water in the surrounding areas (Adamiec et al., 2016). The use of fertilizers and intensive agriculture leads to pollution of organic origin and triggers eutrophication processes in rivers and lakes (Howarth & Marino, 2006).

In the medium term, addressing some of these issues may necessitate developing novel techniques to minimise environmental impacts. However, fostering a shift in habits and lifestyles will be crucially important in the long term. It is vital to recognize that nothing truly vanishes despite investments in equipment and new technologies, particularly non-biodegradable materials that persist and accumulate in nature. Consequently, the future of water on planet Earth hinges on two critical factors: its availability and its chemical (organic and inorganic) and biological quality (Gleick, 2003).

Therefore, this research aims to shed light on the factors that could potentially shape future access to water, encompassing both quantity (water availability) and quality. With shifts in global climate patterns and the introduction of novel substances in our daily routines, new challenges arise in ensuring the provision of high-quality water to communities worldwide. By doing so, this research seeks to foster the responsible management of water resources and promote the well-being of present and future generations.

The chosen methodology for this study is qualitative and descriptive, drawing on the works of Maxwell (1992), Sandelowski (2010), Nassaji (2015), Manjunatha (2019), Elliott & Timulak (2021), and Cropley (2022). Through this approach, the paper offers a comprehensive analysis of water availability and quality, specifically focusing on nutrients, inorganic and organic micropollutants, and biological parameters. Furthermore, it explores the implications of these factors on water's suitability for human consumption and production. Additionally, the paper examines the SRP that contributes to the sustainability of water policy. Ultimately, the authors present their conclusions based on these reflections, offering valuable insights into the subject matter.

2. WATER AVAILABILITY

The exponential growth of the global population in recent decades has raised significant concerns due to the corresponding increase in pressure on natural resources. This phenomenon is particularly evident in the case of water resources. Between 1900 and 1995, the world's water usage witnessed a staggering sixfold increase, surpassing the rate of population growth by more than twice (Shiklomanov, 2000). Furthermore, from 1950 to the early 21st century, water consumption tripled (Gleick, 2003). The demand for agricultural and manufactured goods, as well as for thermal electricity generation and domestic consumption, is expected to result in a projected 55% increase in water withdrawals by 2050 (Lutter, 2016). Regrettably, the consequences of this escalating demand for water are already evident, with approximately 0.5 billion people residing in regions affected by water scarcity (Molden, 2007). Disturbingly, projections indicate that this number could surge to 3 billion by the year 2025 if urgent action is not taken (Boretti &

Rosa, 2019). The impending water scarcity crisis poses a significant threat to Sustainable Development (SD) and calls for immediate attention and concerted efforts on a global scale.

Irrigation is the largest consumer of water by far, using approximately 69% of the total available water, followed by industry at 23%. Consequently, a mere 8% of water, equivalent to an average of 220 liters per person per day, remains available for domestic use (Niemczynowicz, 1999; Xiong et al., 2010). Although the urban population uses only a small volume of available water, it is becoming increasingly difficult to deliver the necessary volume of water to populations, whether for logistical or economic reasons. Estimates predict that by 2050, about 57% of the world’s population will live in areas that suffer water scarcity (Boretti & Rosa, 2019).

Compounding the issue, the global population is increasingly shifting towards urban areas, leading to high population densities within relatively small territorial spaces. This urban migration, coupled with a rise in per capita consumption, intensifies the difficulty in meeting the water demands of these settlements. Approximately 50% of the world's population resides in urban areas, amplifying the urgency of finding viable water supply solutions for these regions. In view of the above, European Union approved Directive 2000/60/EC of the European Parliament and of the Council, of October 23 (EU, 2000), establishing a framework for Community action in the field of water policy.

While sourcing good-quality water for public supply remains a daunting challenge, significant volumes of water are still utilized in sanitary facilities, with the same quality standards as water used for drinking and cooking. However, this fraction constitutes only a small portion of total household consumption. This stems from the prevailing situation where a singular water network serves all purposes, necessitating reconsideration in the future to ensure more efficient water management strategies.

An analysis of the 25 largest cities across America, Africa, Asia, Europe, as well as the five largest cities in Australia revealed that approximately one-third of these cities depend on a substantial portion of their water supply sourced from protected areas (Dudley & Stolton, 2003). Moreover, at least five other cities obtain their water from remote watersheds, some of which are also designated as protected areas (as shown in **Table 1**). Furthermore, it is worth noting that eight cities globally rely on forested regions for their water supply, which is managed with consideration for ensuring water provision to these urban centers (as illustrated in **Table 2**).

Table 1 – Cities in the world for which water is obtained from protected areas

City	Protected area
Bombay, India	Sanjay Ghandi National Park
Jakarta, Indonesia	Gunung Gede Pangrango National Park Gunung Halimun National Park
Tokyo, Japan	Nikko National Park Chichibu-Tama-Kai National Park
New-York, USA	Catskill Mountains
Rio de Janeiro, Brazil	Tijuca National Park Federal Biological Reserve of Tinguá Pedra Branca Park Environmental Protection Area of Gericinó-Mendanha Biosphere Reserve of Mata Atlântica
São Paulo, Brazil	Cantareira Park Ecological Park of Guarapiranga Morro Grande Reserve Ecological Station of Itapeti Juquery Park Alberto Lofgren Park
Madrid, Spain	Natural Park of Peñalara Cuenca Alta del Manzanares Regional Park
Vienna, Austria	Donau-Auen National Park
Ibadan, Nigeria	Forest Reserve of Olokemeji Forest Reserve of Gambari
Cape Town, South Africa	Cape Peninsula National Park Hottentots Holland Natural Reserve
Nairobi, Kenya	Aberdares National Park
Harare, Zimbabwe	Robert McIlwaine National Park Lake Robertson Recreational Park
Sydney, Australia	The Blue Mountains National Park Kanangra-Boyd National Park Nature Reserve of Dharawal
Melbourne, Australia	Kinglake National Park Yarra Ranges National Park Baw Baw National Park

Source: Dudley & Stolton (2003).

However, the increasing population in large cities poses a threat to these protected areas, as the rising water consumption creates pressure on the ecosystem, particularly on water reserves. Moreover, the average rise in temperature can also endanger these protected areas by increasing the likelihood of forest fires.

Table 2 – World cities where there is forest management of the watersheds

City	Forest area management
Seoul, South Korea	The government established a special protection zone around the Nakdong watershed, restricting commercial activities in all watersheds.
Tokyo, Japan	The Tokyo metropolitan area manages the forest area where water is collected for the city, the upper reaches of the Tama River, to increase the capacity for recharging water resources; avoid sedimentation in the Ogochi reservoir; and increase the water purification capacity; and conserve the natural environment.
Beijing, China	The watersheds that feed the Miyun reservoir, the main surface water source for Beijing, are managed to protect the water.
Yangon, Myanmar	The hydrographic basin, containing two dams (Gyo Phyu and Phu Gyi), which feeds the city with water, is managed by the forestry department of Rangoon carries out activities for the conservation of the forest and maintenance and restoration of the hydrographic basin.
Santiago, Chile	The Santiago Hills was classified as an ecological conservation area, so that the space was preserved in a natural state, to ensure and contribute to environmental balance. Forests are the source of drinking water for the metropolitan sanitation company that supplies water to part of the municipality of La Reina (approximately 20% of Santiago's drinking water).
Stockholm, Sweden	The Mälaren and Bornsjön lakes supply the city of Stockholm. The city's water company controls most of the Lake Bornsjön catchment area (5543 ha), of which 2323 ha is occupied by forestry certified by the Forest Stewardship Council. Management is focused on protecting water quality.
Minsk, Belarus	A protected green area, with about 80 km, involving the whole city, allowed the conservation of forests and the protection of water to supply the city.
Munich, Germany	Since the foundation of the water supply system in the city of Munich, in about 1900, forest management has been focused on ensuring good quality water. Currently, an area of 2900 ha is managed, mainly with the objective of ensuring water quality. Additionally, an area of 1900 ha is made available to local farmers, who undertake to carry out certified organic farming.

Source: Dudley & Stolton (2003).

The growth of the world population not only leads to an increase in water demand but also results in an increase in energy needs. Meeting the growing energy demand will require the construction of new nuclear and thermoelectric plants, which utilize coal, natural gas, or biomass, and require significant amounts of water for the cooling process during energy production (as shown in **Figure 1**). Although some of the water used in the process is returned to the water source, a significant amount is lost as steam. According to Sovacool & Sovacool (2009), nuclear power plants require approximately 163 liters of water for each kWh generated, coal power plants and waste incinerators need around 136 liters for each kWh, and natural gas plants require 53 liters. On average, the energy production process requires 95 liters of water for each kWh produced, with approximately 2 liters lost as steam, and the remaining amount being returned to the water source.

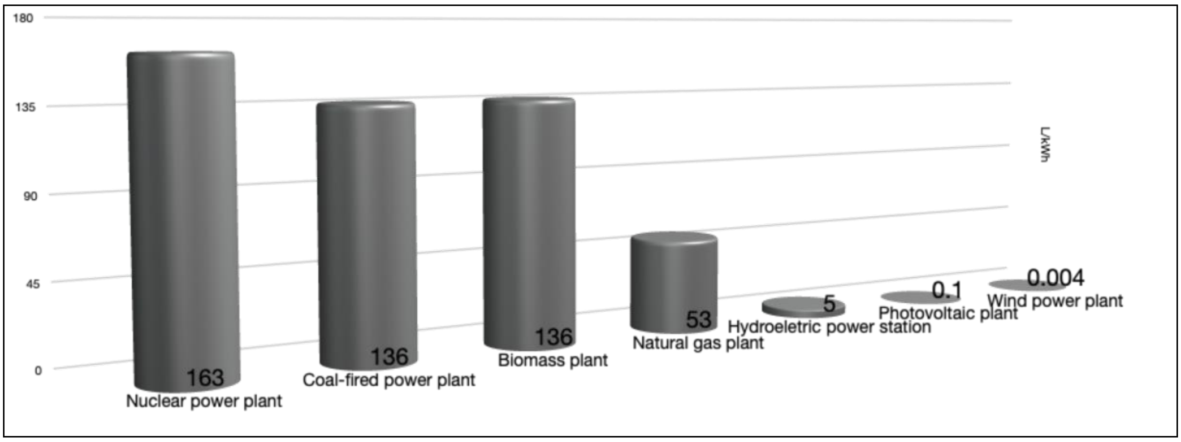

Figure 1: Water consumption in conventional and renewable energy generation (L/kWh)

Source: Sovacool & Sovacool (2009).

However, population growth not only increases the demand for energy but also necessitates greater food production. Water is a crucial factor in agricultural production, and its availability is essential for ensuring food security. According to FAO (2011), agriculture accounts for 69% of global water withdrawals. While water is essential for food security, its demand is growing for other purposes, such as urban and industrial activities, leading to the degradation of water quality and hindering its use in food production. Climate change poses a significant threat to water availability, both in terms of space and time, which in turn puts food production under pressure (UN, 2020).

Certain regions of the world will experience an escalating scarcity of water, and even if new water sources are utilized, they will not be sufficient to meet the needs of a growing global population (Brown & Funk, 2008). Climate change is likely to lead to more frequent and more severe supply and demand shocks, which will pose a challenge to the formulation of monetary policy (Kabundi et al., 2022). On the supply side, extreme weather events, such as droughts, will likely increase food price volatility. While shocks may be two-sided, adverse supply shocks create difficult trade-offs for monetary policy since they may push prices up and output down (Klomp, 2020).

In summary, the growth of the world population will lead to heightened demand for water in various sectors, including agriculture, energy production, and domestic, and industrial use. While the overall amount of water available remains constant, the quality of water is likely to deteriorate as efforts are made to meet the needs of the expanding population. To address these challenges, it is crucial to implement sustainable water management practices, promote water conservation and efficiency, and invest in alternative water sources and technologies. Additionally, addressing pollution sources and improving wastewater treatment can help safeguard water quality and ensure its availability for future generations.

3. WATER QUALITY

Droughts and floods are significant consequences of climate change that greatly affect water availability, particularly regarding drinking water (see **Figure 2**). During dry periods, a change in water quality is expected due to the higher concentration of chemical compounds resulting from water evaporation. Conversely, floods contribute to the degradation of surface water quality through the partial erosion and transport of soil and its constituents. The increased presence of suspended organic and inorganic material in the water leads to a decline in the quality of water catchments, posing significant challenges for Water Treatment Plants (WTPs).

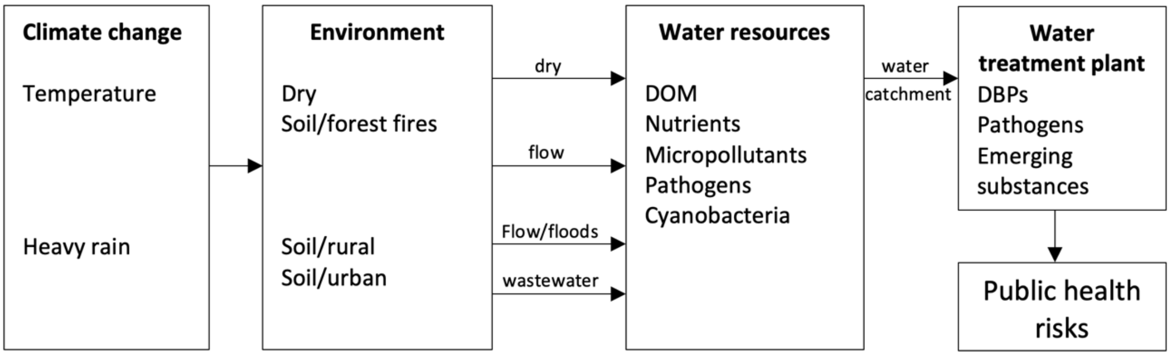

Figure 2: Impacts of climate change on water resources and the quality of drinking water

Source: Delpla et al. (2009).

However, climate change is not the sole factor that affects water quality. Other factors, such as land use, deforestation, urbanization, population growth, and the prevalence of intensive consumption patterns, also have a significant impact on the quality of both surface and groundwater. As human activities are directly linked to water pollution, climate change may indirectly amplify the effect of these activities on water quality. Therefore, addressing water pollution requires a comprehensive approach that considers both climate change mitigation and the mitigation of other human-induced factors.

The temperature of water bodies in Europe, North America, and Asia have been increasing since 1960, primarily due to the warming of the atmosphere caused by an increase in solar radiation (Bates et al., 2008). This temperature rise leads to an increase in water pH due to a decrease in the concentration of carbon dioxide and oxygen. The decrease in oxygen concentration may also be linked to an increase in the assimilation of organic compounds by microorganisms (Prathumratana et al., 2008). Additionally, rising temperatures enhance the likelihood of forest fires, which release significant amounts of nitrogen (N) and phosphorus (P) into the water. The introduction of high concentrations of N and P into the water poses ecological and public health concerns, as excessive levels of nitrates and nitrites pose a risk, particularly in the formation of nitrosamines in WTPs.

Moreover, the rise in average temperatures can also lead to an increase in the concentration of ions and heavy metals in water, especially in alpine regions, as described by Thies et al. (2007). This is because the increase in Dissolved Organic Matter (DOM) can contribute to the complexation and transport of metals (Rothwell et al., 2007), affecting the functioning of aquatic ecosystems but also influencing the quality of drinking water. An increase in organic carbon content and a decrease in redox conditions can further contribute to the increase of metals in water. Nonetheless, in recent decades, efforts to treat wastewater from industrial and urban areas have resulted in a reduction in the concentration of metals in surface and groundwater in Western countries. This reduction is partly attributed to the relocation of some industries to countries with cheaper labor, as well as the implementation of environmental protection regulations, such as the elimination of lead in gasoline.

Anyway, surface waters are highly affected by both natural and anthropogenic activities, with precipitation, seasonality, intensity, and average temperature playing a major role in the fate of the chemicals. Forest fires are also significant contributors to the increase in chemical substances in surface waters. Ashes from forest fires, which remain in the soil after the fire, contain high concentrations of nutrients, trace elements, and other potential contaminants (see **Table 3**).

Table 3 – Chemicals originated after forest fires and their risks to human health

Chemicals	Source	Risks
Aluminum	Leaching of soils and rocks	Neurotoxic
Ammonia	Microbial metabolism, fertilizers, and animal waste	Corrosion
Arsenic	Dissolution of minerals	Carcinogen
Barium	Soils and rocks	Vasoconstrictor
Chromium	Soils and rocks	Hexavalent chromium is carcinogenic
Cyanides	Biomass burning, natural plant decomposition	Highly toxic, affects thyroid and central nervous system (CNS)
Lead	Dissolution through natural resources	Toxic effects on the CNS
Mercury	Burning coal	Toxic (Kidneys)
Organic Carbon	Soil, sediment, organic matter, ash	Disinfection by-products (DBP), Trihalomethanes (THM)
Dibenzodioxins, Dibenzofurans	Produced during forest fires (accumulation in soil and sediment)	Toxic, carcinogenic
Polycyclic aromatic hydrocarbons	Incomplete combustion of organic matter (forest fires, volcanic eruptions)	Carcinogenic and mutagenic

Source: Smith et al. (2011).

Therefore, it is essential to implement effective measures targeted at reducing nutrient inputs into water bodies (Shortle et al., 2020). This can be achieved through various actions, including but not limited to:

- **Enhancing agricultural practices**: encouraging the adoption of sustainable farming techniques and promoting the use of organic fertilizers and implementing nutrient management plans can help maintain nutrient balance in agricultural systems;
- **Upgrading wastewater treatment systems**: investing in advanced wastewater treatment technologies and infrastructure upgrades can significantly reduce the release of nutrients into water bodies;
- **Implementing riparian buffer zones**: establishing vegetated buffer zones along water bodies can act as a natural filter, reducing the transport of nutrients from adjacent agricultural lands; and
- **Promoting watershed management approaches**: adopting holistic approaches to managing watersheds can address nutrient pollution at a broader scale, involving various stakeholders, such as farmers, industries, and local communities.

By implementing these measures, is possible effectively reduce nutrient inputs, safeguard aquatic ecosystems, and ensure the long-term sustainability of our valuable water resources.

4. IMPACTS ON THE PRODUCTION OF WATER FOR HUMAN CONSUMPTION

Chemical compounds produced or used in our activities, as well as their by-products, inevitably find their way into the environment and can be found in water sources intended for human consumption. Therefore, regardless of the source of pollution, whether natural or anthropogenic, pollutants will be present in untreated water used for producing drinking water. Several factors, such as temperature, dissolved organic carbon, pH, bromide concentration (see **Figure 3**), and operational variables like chlorine dosage or contact time, are relevant in the formation of Disinfection By-Products (DBPs) (Nikolaou et al., 2004; Rodrigues et al., 2007; Teksoy et al., 2008; Platikanov et al., 2010). Higher temperatures promote a faster rate of DBPs formation. Conversely, storm events that introduce organic matter into water sources also contribute to elevated levels of DOM and, consequently, increase the production of DBPs.

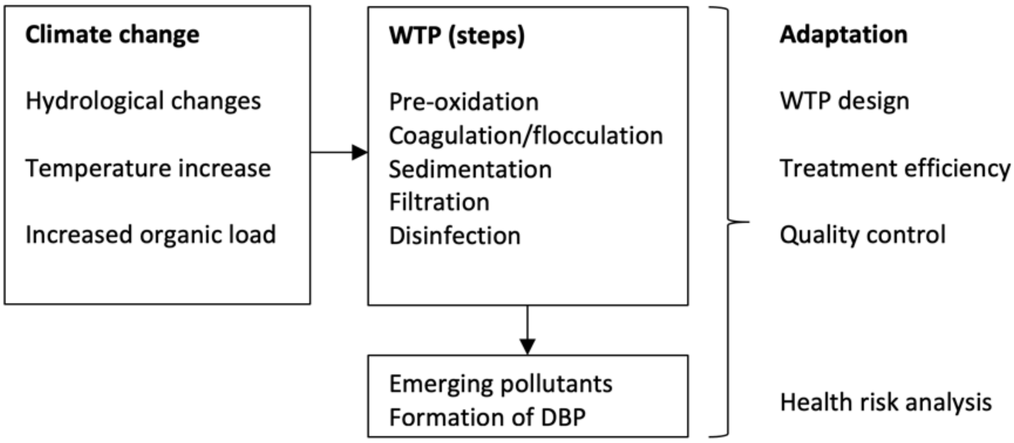

Figure 3: Impact of climate change on water treatment processes for human consumption

Source: Delpla et al. (2009).

Forest fires can also result in higher concentrations of Dissolved Organic Carbon (DOC), which can be transported into water bodies, causing issues in water disinfection, and affecting aesthetics such as taste, smell, and color. However, DOC is not the sole parameter that undergoes significant changes following a storm or forest fire. The increased nutrient concentrations in the water can stimulate the growth of aquatic plants, algae, and cyanobacteria during the summer, further exacerbating the formation of DBPs, especially haloacetic acids. Additionally, toxins that pose challenges for removal in WTPs may also emerge.

Other micropollutants of concern include pharmaceutical compounds. Recent studies have shown that these compounds are not eliminated during wastewater treatment and can enter the water environment, potentially reaching watersheds and even our drinking water. Even if these compounds undergo partial removal at Wastewater Treatment Plant (WWTP), residual amounts may still be present in the treated water that is consumed daily. Bisphenol-A is another micropollutant that can be found in treated wastewater and can enter WTPs via raw water.

In 2009, Benotti et al. conducted a study to examine the presence of pharmaceutical compounds and endocrine disruptors in raw water and water treated in a WTP. The WTP selected for the study used a combination of treatments, including pre-oxidation (using chlorine, chlorine dioxide, or ozone), coagulation-flocculation, sedimentation, filtration, and final disinfection. Out of the 51 compounds analyzed, 34 were detected in at least one of the samples. Although most of these compounds were detected in raw water, their presence was also observed after treatment. Among the 18 samples of treated water analyzed, 16 showed the presence of at least one of the analyzed compounds. The study also analyzed water from the distribution system and found detectable quantities of at least one compound in 13 out of 15 samples.

Pesticides are chemical compounds extensively utilized in modern societies, especially in agriculture. Although conventional treatment methods like coagulation/flocculation, sedimentation, softening, and filtration are efficient in eliminating lipophilic pesticides, the removal of hydrophilic pesticides can be more challenging. These hydrophilic pesticides tend to persist and may not be eliminated through the treatment processes. Consequently, the presence of these compounds in drinking water can pose a potential health risk to consumers, being crucial to implement comprehensive monitoring and advanced treatment strategies to address the persistence of hydrophilic pesticides and ensure the safety of drinking water supplies.

5. SUSTAINABLE DEVELOPMENT POLICY

Ensuring access to safe and reliable drinking water is crucial for the well-being and health of individuals and communities, making it a fundamental component of SDP. These policies aim to utilize resources in a manner that meets the needs of the present generation while also ensuring the ability of future generations to meet their own demands

(UN, 1987). In line with the SRP advocated by Schaltegger et al. (1996), such policies prioritize transparency, accountability, and sustainability. Additionally, Crowther & Rayman-Bacchus (2004a) emphasized the importance of the social contract in promoting responsible resource management.

Crowther & Rayman-Bacchus (2004b) consider that the principle of:

- '**Transparency**' means all the effects of the actions of the organization, including external impacts, should be apparent to all stakeholders through the information provided by the reporting mechanisms;
- '**Accountability**' entails the recognition that an organization's actions have consequences for the external environment and involves taking responsibility for those effects;
- '**Sustainability**' recognizes that if resources are utilized in the present, they may no longer be available for use in the future, particularly when resources are finite in quantity; and
- '**Social contract**' entails organizations willingly entering a contract with society. In doing so, they voluntarily relinquish certain rights in favor of third parties to promote the advantages of social order, putting the interest of the individual above the interest of the collective.

By incorporating these principles, SDP recognizes the importance of effective water resource management to ensure their long-term availability. This involves considering the quantity of drinking water needed to meet the demands of growing populations and evolving consumption patterns. Sustainable water management strategies focus on achieving a balance between water supply and demand, promoting water conservation practices, and establishing efficient water distribution systems. By addressing the quantity aspect of drinking water, SDP fosters a sense of social responsibility and guarantees equitable access to water resources, enabling their responsible conservation and utilization for the well-being of present and future generations.

Indeed, pollution, over-extraction, and mismanagement of water resources can have detrimental effects on water quality and ecosystem health. To tackle these issues, SDP promotes a range of measures to prevent water pollution, enhance water treatment technologies, and implement comprehensive watershed management approaches. These policies aim to safeguard water quality, maintain the ecological balance of aquatic systems, and support the long-term sustainability of biodiversity. By addressing these challenges, SDP strives to protect the integrity of water ecosystems and ensure the availability of clean and healthy water for both human and ecological needs. Moreover, these policies recognize the interdependence of human well-being and ecosystem health, emphasizing the importance of sustainable practices to preserve water resources for future generations.

This reinforces the argument that implicit in the concept of SD is intergenerational equity, which recognises the importance of considering both the short and long-term implications of SD (Dernbach, 1998). Scholars such as Kolk (2016), Gossling-Goidsmiths (2018), and Zhai & Chang (2019) argue that achieving intergenerational equity requires the integration of environmental, economic, and social concerns in decision-making processes. In this way, the most optimal choices are those that fulfill the needs of society while also being environmentally and economically viable, socially equitable, and socially and environmentally bearable (Porter & van der Linde, 1995). To capture the interconnectedness among the environmental, economic, and social aspects of SD, three interconnected spheres of sustainability can be identified (as shown in **Figure 4**).

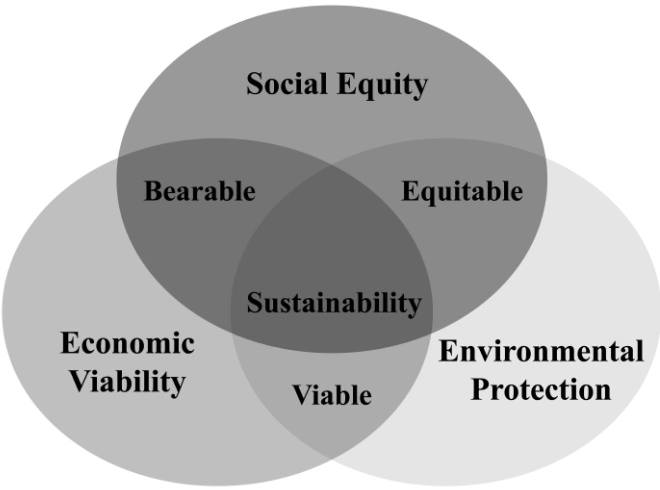

Figure 4: Relationships among environmental, economic, and social sustainability

Source: Mensah (2019).

In the context of drinking water quality and quantity, the relationships among environmental, economic, and social sustainability are deeply interconnected and interdependent. On one hand, environmental sustainability encompasses the protection and conservation of water sources, such as rivers, lakes, and aquifers, as well as the prevention of pollution and degradation (UN, 2018a). The availability of clean and abundant water resources is essential for both human and ecological well-being, and for that is important the responsible and balanced management of natural resources to meet the needs of the present generation without compromising the needs of future generations. On the other hand, economic sustainability involves ensuring that water-related industries, such as water treatment and distribution, operate in a financially viable and efficient manner. It also encompasses cost-effectiveness in infrastructure development, maintenance, and investment, while considering affordability for individuals and communities. Balancing economic sustainability with environmental concerns is crucial to avoid exploitative practices that may harm water resources and adversely impact long-term sustainability (Braden & van Ierland, 1999).

Furthermore, social sustainability addresses equitable access to safe and affordable water for all citizens, irrespective of their socioeconomic status or geographical location, including education and awareness programs to promote responsible water usage and conservation, fostering a sense of stewardship among individuals and society (UN, 2022). Social equity should be at the forefront of decision-making processes and not should economic considerations overshadow environmental concerns. In this sense, ensuring the sustainability of our water resources and addressing drinking water quality and quantity issues necessitates an integrated approach that considers environmental, economic, and social factors. By recognizing the interplay between these dimensions, is possible to work towards a more resilient and equitable water future, safeguarding the well-being of both present and future generations.

To effectively address the challenges of sustainability and the process of its development, several strategies can be implemented to ensure the quality and quantity of drinking water, both now and in the future. These strategies include:

- **Sustainable Water Management**: helps to reduce the strain on water reserves. This involves implementing efficient water use technologies, promoting water conservation and reuse, investing in infrastructure for water treatment and distribution, supporting research and innovation, and fostering collaboration between stakeholders across sectors;
- **Urban Planning**: plays a crucial role in mitigating the adverse effects of urbanization on protected areas. The development of green infrastructure, such as parks and urban forests, can foster ecological connectivity and enhance the overall resilience of ecosystems. By integrating nature into urban design, we can create sustainable and harmonious urban environments that support biodiversity and provide multiple benefits for both residents and the natural world.

Furthermore, other urban solutions can be implemented, such as rainwater harvesting and its use for non-potable purposes, such as irrigation systems, reducing the pressure on the urban drinking water supply;

- **Public Awareness and Education**: Creating public awareness about the significance of water quality and the threats related to its quantity is crucial. Education campaigns can play a vital role in promoting responsible behavior, such as minimizing water consumption, preventing wildfires, and respecting protected areas. Engaging local communities and stakeholders in conservation efforts fosters a sense of ownership and stewardship. By empowering individuals with knowledge and encouraging sustainable practices, public awareness and education initiatives contribute to the long-term preservation of water resources and ecosystems;
- **Collaborative Governance**: Establishing effective governance structures that promote collaboration among government agencies, local communities, NGOs, and other stakeholders is crucial. This collaborative approach facilitates coordinated efforts in managing protected areas, addressing water consumption issues, and implementing sustainable development practices. By fostering partnerships and involving diverse perspectives, collaborative governance enhances the effectiveness and inclusivity of decision-making processes, leading to more sustainable outcomes and greater community engagement;
- **International Cooperation**: encouraging international cooperation and sharing best practices among countries can effectively address the challenges arising from drinking water shortages and deterioration. Collaboration in areas such as research, knowledge exchange, and capacity building can significantly enhance efforts to promote sustainable development. By leveraging collective expertise and resources, international cooperation maximizes the impact of initiatives aimed at addressing drinking water challenges and advancing sustainable development goals.

Therefore, by implementing these strategies, it is possible to mitigate the threats posed by the increasing population in large cities and protect the ecosystems. This collaborative approach strengthens the collective ability to tackle the global water crisis and achieve long-term sustainability.

5. CONCLUSIONS

The concern for the future of water on planet Earth is felt in both qualitative and quantitative aspects. Water quality refers to the chemical, physical, and biological characteristics of water that determine its fitness for specific uses, including drinking. Maintaining high water quality standards is essential to prevent waterborne diseases and protect public health. Water quantity, on the other hand, refers to the availability and adequacy of water resources to meet the demands of various sectors, including domestic, agricultural, and industrial uses. Balancing water quantity and ensuring an adequate supply is crucial to avoid water scarcity, conflicts, and social disruptions.

Climate change has a significant impact on water quality and increases the risk of health hazards and ecosystem imbalances during extreme weather events. Furthermore, water pollution is also increasing due to the rising levels of dissolved organic matter, including pharmaceuticals, medical diagnostics, and personal hygiene products, among others. Despite the human and financial costs involved, there is a pressing need to increase water quality surveillance, particularly for emerging contaminants. However, it is crucial to note that even with improved treatment systems and increased surveillance, the emission of pollutants must be reduced to effectively address the issue. This highlights the need for sustained and coordinated efforts to reduce the sources of water pollution and protect water resources for future generations.

In summary, the relationship between the quality and quantity of drinking water and the SDP is one of mutual dependence and interconnection. SDP aim to ensure access to safe and sufficient drinking water while considering the long-term availability of water resources and the preservation of ecosystems. By integrating drinking water concerns into broader sustainability frameworks, these policies promote a balanced and holistic approach to water management. This approach benefits society, the environment, and future generations by safeguarding public health, supporting sustainable water resource utilization, and fostering the preservation of ecosystems. The integration of drinking water considerations within SDP helps create a comprehensive and inclusive approach to water management that addresses economic, environmental, and social dimensions, ultimately advancing the well-being and prosperity of communities worldwide.

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