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Drinkable water problem in comparison with developed and developing countries - executive and management solution insights to the issue

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Abstract

The increasing problem of water scarcity poses a significant challenge worldwide, impacting both developed and developing countries. The main aim of this study is to provide a thorough analysis of the disparities in water availability, quality, and management in numerous settings. It particularly explores the impact of technological advancements, governance frameworks, and financial investments. Developed countries reap the advantages of well-established infrastructure, rigorous regulatory systems, and significant technological investments, which guarantee reliable and uninterrupted access to clean water. On the other hand, developing nations face a range of challenges such as insufficient infrastructure, limited financial resources, ineffective governance, and a high prevalence of waterborne diseases. It is crucial to implement strategies tailored to specific regions that utilize breakthroughs in technology, boost regulatory frameworks, and encourage community involvement in order to accomplish water security and resilience. This study proposes a thorough analysis of the factors that contribute to disparities in water security through the examination of case studies, regulatory frameworks, and technological developments. The findings underscore the significance of international cooperation and financial obligations to guarantee fair and widespread availability of safe drinking water. Furthermore, it is essential to address the quantity as well as the purity of water to mitigate the threat to public health and promote sustainable development. Efficient methods of water management are crucial for the well-being of society, as well as for the economic and environmental aspects of sustainability. The intention is to make an invaluable addition to the worldwide discussion on water security by providing practical insights and recommendations for policymakers and stakeholders in developed and developing nations. By working together, we can improve water management practices, address inequalities, and ensure a sustainable and healthy future for everyone.

Keywords: Technological advancements, Water security, Water management, Drinking water, Sustainable development.

Resumo

O problema crescente da escassez de água representa um desafio significativo a nível mundial, afetando tanto os países desenvolvidos como os países em desenvolvimento. Este estudo tem como principal objetivo fornecer uma análise exaustiva das disparidades na disponibilidade, qualidade e gestão da água em vários contextos. Explora particularmente o impacto dos avanços tecnológicos, dos quadros de governação e dos investimentos financeiros. Os países desenvolvidos beneficiam das vantagens de infraestruturas bem estabelecidas, sistemas regulamentares rigorosos e investimentos tecnológicos significativos, que garantem um acesso fiável e ininterrupto à água potável. Por outro lado, os países em desenvolvimento enfrentam uma série de desafios, tais como infraestruturas insuficientes, recursos financeiros limitados, governação ineficaz e uma elevada prevalência de doenças transmitidas pela água. É crucial implementar estratégias adaptadas a regiões específicas que utilizem os avanços tecnológicos, reforcem os quadros regulamentares e incentivem o envolvimento da comunidade, a fim de alcançar a segurança e a resiliência da água. Este estudo propõe uma análise exaustiva dos fatores que contribuem para as disparidades na segurança da água através do exame de estudos de caso, quadros regulamentares e desenvolvimentos tecnológicos. As conclusões sublinham a importância da cooperação internacional e das obrigações financeiras para garantir a disponibilidade justa e generalizada de água potável. Além disso, é essencial abordar a quantidade e a pureza da água, a fim de atenuar a ameaça à saúde pública e promover o desenvolvimento sustentável. Métodos eficientes de gestão da água são cruciais para o bem-estar da sociedade, bem como para os aspetos económicos e ambientais da sustentabilidade. Pretende-se, assim, contribuir de forma inestimável para o debate mundial sobre a segurança da água, fornecendo perspetivas e recomendações práticas para os decisores políticos e as partes interessadas nos países desenvolvidos e em desenvolvimento. Trabalhando em conjunto, podem melhorar-se as práticas de gestão da água, combater as desigualdades e garantir um futuro sustentável e saudável para todos.

Palavras-chave: Avanços tecnológicos, Segurança da água, Gestão da água, Água potável, Desenvolvimento sustentável.

Abstrakt

Artan su qıtlığı problemi həm inkişaf etmiş, həm də inkişaf etməkdə olan ölkələrə təsir etməklə bütün dünyada ciddi problem yaradır. Bu tədqiqat çoxsaylı parametrlərdə suyun mövcudluğu, keyfiyyəti və idarəolunmasında olan bərabərsizliklərin hərtərəfli təhlilini təqdim edir. Bu, xüsusilə texnoloji irəliləyişlərin, idarəetmə çərçivələrinin və maliyyə investisiyalarının təsirini araşdırır. İnkişaf etmiş ölkələr təmiz suya etibarlı və fasiləsiz çıxışı təmin edən yaxşı qurulmuş infrastrukturun, ciddi tənzimləmə sistemlərinin və əhəmiyyətli texnoloji investisiyaların üstünlüklərini əldə edirlər. Digər tərəfdən, inkişaf etməkdə olan ölkələr qeyri-kafi infrastruktur, məhdud maliyyə resursları, səmərəsiz idarəetmə və su ilə yoluxan xəstəliklərin yüksək sürətlə yayılması kimi bir sıra problemlərlə üzləşirlər. Texnologiyada irəliləyişlərdən istifadə edən, tənzimləyici çərçivələri təkmilləşdirən və su təhlükəsizliyinə və dayanıqlılığa nail olmaq üçün cəmiyyətin iştirakını təşviq edən spesifik regionlara uyğunlaşdırılmış strategiyaların həyata keçirilməsi çox vacibdir. Bu tədqiqat nümunələrin, tənzimləyici çərçivələrin və texnoloji inkişafların araşdırılması yolu ilə su təhlükəsizliyində bərabərsizliklərə səbəb olan amillərin hərtərəfli təhlilini təklif edir. Nəticələr təhlükəsiz içməli suyun ədalətli və geniş şəkildə mövcudluğunu təmin etmək üçün beynəlxalq əməkdaşlığın və maliyyə öhdəliklərinin əhəmiyyətini vurğulayır. Bundan əlavə, əhalinin sağlamlığı üçün təhlükəni azaltmaq və davamlı inkişafı təşviq etmək üçün suyun kəmiyyətinə və saflığına diqqət yetirmək vacibdir. Suyun idarə edilməsinin səmərəli üsulları cəmiyyətin rifahı, eləcə də davamlılığın iqtisadi və ekoloji aspektləri üçün çox vacibdir. Əsas məqsəd inkişaf etmiş və inkişaf etməkdə olan ölkələrin siyasətçiləri və maraqlı tərəfləri üçün praktiki fikirlər və tövsiyələr verməklə su təhlükəsizliyi ilə bağlı dünya müzakirələrinə qeydə dəyər əlavə etməkdir. Birgə işləməklə biz su idarəçiliyi təcrübələrini təkmilləşdirə, bərabərsizlikləri aradan qaldıra və hər kəs üçün davamlı və sağlam gələcəyi təmin edə bilərik.

Açar sözlər: Texnoloji inkişaf, Su təhlükəsizliyi, Su idarəetməsi, İçməli su, Davamlı inkişaf.

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Abbreviations and Acronyms

DBPs: Disinfection By-Products
DWSRF: Drinking Water State Revolving Fund
EPA: Environmental Protection Agency
ERDF: European Regional Development Fund
EU: European Union
FAO: Food and Agriculture Organization
GDP: Gross Domestic Product
Gov.: Government
IMF: International Monetary Fund
Inc.: Incorporated
IP: Internet Protocol
IWRM: Integrated Water Resources Management
Ltd.: Limited
MAR: Managed Aquifer Recharge
MCL: Maximum Contaminant Level
MDGs: Millennium Development Goals
NGOs: Non-Governmental Organizations
OECD: Organisation for Economic Co-operation and Development
PPCC: Intergovernmental Panel on Climate Change
PPPs: Public-Private Partnerships
PUB: Public Utilities Board (Singapore)
RBF: River Bank Filtration
SDGs: Sustainable Development Goals
SDWA: Safe Drinking Water Act
UBA: German Environment Agency
UN: United Nations
UNESCO: United Nations Educational, Scientific and Cultural Organization
UNICEF: United Nations International Children's Emergency Fund
UN-MDGs: United Nations Millennium Development Goals
UV: Ultraviolet
VLDA: Vulnerability Level Determination Analysis
WASH: Water, Sanitation, and Hygiene
WFD: Water Framework Directive
WHO: World Health Organization
WWAP: World Water Assessment Programme
WWF: World Wildlife Fund

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Introduction

The increasingly alarming threat of water scarcity is now a pressing issue worldwide, and thus, coordinated actions from both public and for-profit sectors are a crucial formula to tackling the challenges of declining freshwater resources. The research will thoroughly analyze the water situation as a multi-layered problem, exposing its impacts on the private sector and governmental entities while stressing the fundamental need for green solutions.

A scarcity of water can have the propensity to set off conflicts in a country where water resources are scarce. International disputes around shared water resources can sometimes escalate the existing tension in their regions and, at times, even disrupt the cooperative efforts to address the issue collectively (Ansell & Torfing, 2021). Hence, appreciating the multidimensional elements of the drinkable water crisis not only lays the ground for implementing well-tailored strategies and applications but also promotes tension-free access to fresh and clean water for everyone. It is not enough to know the gravity of the world's water crisis separately, one must truly understand the scope of its global impacts.

Safe and drinkable water is essential to human existence and growth as it is a "necessity" for almost all human endeavours and is necessary for long-term sustainable development. Unsafe water has a huge detrimental effect on people's health, productivity as a country, quality of life, and socioeconomic progress. The reason for this is because water is essential to human life in terms of security and socioeconomic activities including transportation, agriculture, production, local and international consumption, and the preservation of healthy ecosystems (Widuto, 2018). The biosphere and planetary life depend on water, which has to be sufficient, uniformly distributed, reliable, equally accessible, clean, safe, and acceptable (Vorosmarty, Green, Salisbury, & Lammers, 2000). The demand for clean water is also kept lower than the supply when this condition is met. When a nation's water quality is adequate, it serves as a key predictor of social progress, public health, and the quick growth of that nation. However, dirty water spreads infections and poses a risk to human health, which lowers productivity rates on an individual basis (Vorisek & Yu, 2020).

Safe water supply as well as fundamental water-related sanitation and hygiene procedures are required. Due to limited or nonexistent government interest in water-related problems and low levels of investment in infrastructure for water treatment and delivery, the benefits of clean and drinkable water are not well documented in developing nations. You may find it interesting to learn that, based on the few data available, water plays a major role in these nations' remarkable economic progress. Due to its intricate relationship with industrialisation, agriculture/food production, and energy production, water alone has a very high benefit-cost ratio of more than in developing continents like Africa and Southern America. In some other countries, this ratio may reach 7:0, with a minimal recorded value of 2:0 worldwide. This

means that, in addition to other technical, environmental, and political benefits, poor nations will see an increase in their economies of between 5 and 30 USD for every $1 invested in water resource management (Unicef, 2018). The water sector plays a vital role not only in economic development but also in the development of other aspects of national growth due to its interconnected relevance with other developmental sectors at local, national, regional, and international levels, including the household, health, agriculture and food, energy and power, industry and manufacturing, environmental, educational, legal, and political (Uhlenbrook & Connor, 2019).

The cost-effectiveness of water significantly impacts how much is used and which sources are preferred. Compared to families linked to a piped water system, those with really poor access to a potable water system often pay more for their water. Due to the high cost of water, those who have the least access to potable water may be forced to utilise worse quality water from other sources, which poses a greater danger to their health. Moreover, excessive water costs may cause families to use less water, which might have an impact on cleanliness and raise the risk of disease transmission. It is important to gather information on the cost at the time of purchase when evaluating the affordability of potable water. Nevertheless, this can be the charge if homes are linked to the potable water provider. However, if water is obtained from nearby neighbours or public standpipes, the price at the time of purchase could fluctuate significantly from the provider rate. Costs are associated with a variety of potable water sources, most notably suppliers, and they should be considered when evaluating affordability. When determining affordability, one should additionally include in the fees associated with a basic connection purchase in addition to recurring charges (Shah, 2016).

The research focuses on how to navigate through the drinkable water problem by exploring literature written on the topic by several authors who contributed to the issue from different perspectives, namely, scientific approaches and public policy perspectives. Meanwhile, theme overview identifies the general view for the readers of the extent to which drinkable water concerns both developed and developing countries. In the research methodology part, the problem statement was explained, identifying research questions, which are stated as follows: to what extent does the emerging drinkable water problem constrain businesses, how is the drinkable water problem challenged by the drinkable water problem, and through globalisation which measures should be taken to facilitate the problem for future generations. Furthermore, in the empirical part, the survey results are interpreted by comparing results with the past and future aspects. In the end, the research has been concluded by diagnosing the potential remedies for the problem. The ending results suggested that the public and private partnership, community initiatives, public awareness, and knowledge transfer together with financial support in between developed and developing nations could impact highly positive on the drinkable water problem within the context of this research.

1. Themes of Literature Review

1.1. Essential Elements in Drinking Water

To understand the problems associated with drinkable water, there is a need to understand the essential elements within water. The effects of trace elements are not as straightforward since the presence of trace elements in an animal or human body is very small but their influence on the health of animals and people is significant (Cannas et al., 2020). Despite the toxic nature of some nutrients, these nutrients are essential in growth, development, and the prevention of diseases. These elements are parts of immune activities as well as they are acting as cofactors of some vital enzymes and antioxidants. Hence, it would depend on the tissue concentration and the levels of these elements in our bodies. Moreover, it is critical that current legislative values of trace element concentrations in foods and water need to be revised and adjusted. This review focuses on the possible correlation between trace elements, specifically types of metals found in blood samples, and autoimmune diseases, including type 1 diabetes and multiple sclerosis. Furthermore, it presents the current laws demonstrates the gap in the existing legislation, and stresses the importance of trace nutrients in metabolism and health.

Surface water is one of the most critical environmental compartments affected by 1,4 Dioxane, thereby making it a current and increasing concern since the US EPA categorized it as a class 2B carcinogen (Karges et al., 2020). In this process, comprehending the dispersion of 1,4-Dioxane in finished drinking water procured through MAR systems when businesses deal with environmental restrictions is relevant. This research aimed at analyzing 1,4-Dioxane concentration in final drinking water derived from MAR, including River bank filtration (RBF) or Artificial Groundwater Recharge (AGR). Findings show that there is a high probability of 1,4-Dioxane contamination in approximately half of the analyzed samples and, therefore, call for strict monitoring of the water production processes for value-added businesses in water management systems. Thus, when these gaps are filled, one would reduce potential threats to public health by providing accurate information on dietary habits and enhancing the formulation of informed regulations.

Another study by Srivastav and colleagues (2020) is devoted to the issue of DBPs in drinking water, demonstrating their appearance, the degree of hazard, and possible ways to solve this problem. DBPs that are formed due to disinfection processes are rather dangerous to health, such as causing neoplasm, cytotoxic effects, and mutagenic effects. Extensive details on different levels of disinfection performed at the municipal level and the risks posed by DBP are provided in the paper. Further, it explores the state of affairs of water safety around the world and demonstrates some broad removal methods like adsorption and advanced oxidation processes for removing DBP from water sources.

Through the assessment of DBP occurrence, toxicity, and mitigation alternatives, the study offers crucial information regarding protective measures against adverse health effects related to DBPs in drinking water, emphasizing the significance of adopting adequate water management processes to ensure the safety and quality of the drinking water supply for the community. The illustration of these findings is as follows (Figure 1).

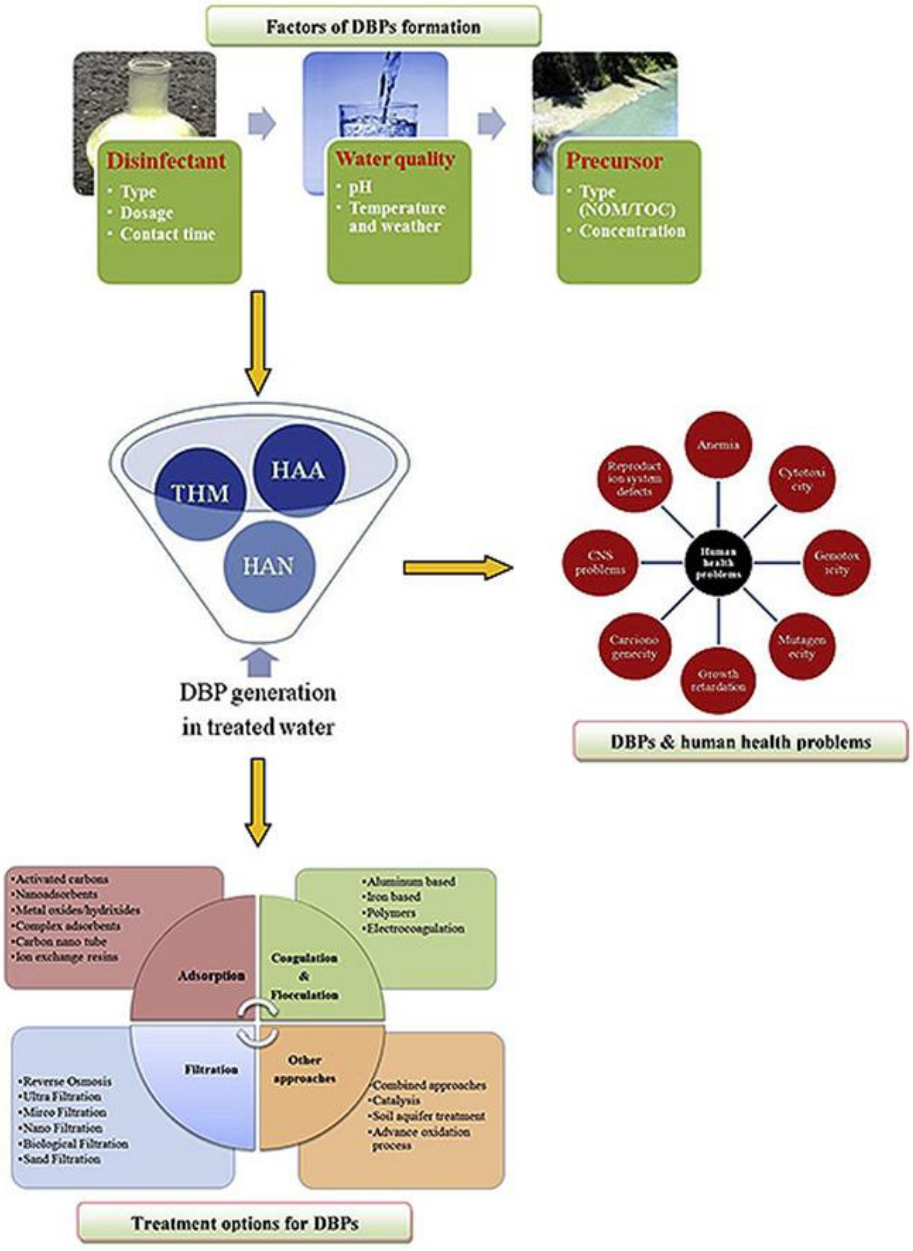

Figure 1. Factors of DBP Formation.

Source: Srivastav et al. (2020, p.4, 6, 9).

1.2. Water Scarcity

Water scarcity, characterized by the fact that water is either unavailable or inaccessible to people, has been identified to be a key issue in numerous parts of the world caused by several interconnected factors (Droege et al., 2021). The driven world population, the speedy urbanisation, and the spreading industry activities are greatly focusing on the use of water. Along with this, climate change is taking things to the next level by deviating precipitation patterns, starting recurrent droughts, and carving into glaciers in many regions. This, however, is counterproductive to the well-being of most regions. At Table 1, the adapted version of the overall situation in terms of indication shows the extent to which the problem is enhanced over the course of well-being and specific factors that separately contribute to the expansion of the matter on different realms.

Table 1. Water Scarcity.

Key operations and processes	
Regulation/legislation	*Marimba et al*., *2010*; *Mendoza et al*., *2019a*
Service provision	Nunes et al., 2018; *Junnila*, 2006, 2009; *Malik et al*., *2018*; *Mendoza et al*., *2019a*; *Shrake et al*., *2011*, *2013*
CE projects	Mendoza et al., 2019a; Nunes et al., 2018; *Marimba et al*., *2010*; *Kubler et al*., *2019*
Education/Awareness	Mendoza et al., 2019a; *Nunes et al*., *2018*; *Marimba et al*., *2010*; *Shrake et al*., *2013*
Internal CE strategy	Fonseca et al., 2018; *Nunes et al*., *2018*; *Marimba et al*., *2010*
Biodiversity actions	Nunes et al., 2018
Commuting/transport	Junnila, 2009, 2006; Marimba et al., 2010; Marique and Rossi, 2018; Nunes et al., 2018; Shrake et al., 2013, 2011
IT-Performance	Kubler et al., 2019; Shueb and Mir, 2014; *Malik et al*., *2018*
Administration	Malik et al., 2018; Mendoza et al., 2019a; Shrake et al., 2013, 2011; Unger et al., 2016; *Junnila*, 2006, 2009; *Marimba et al*., *2010*
Auditing	Marimba et al., 2010; Shrake et al., 2013, 2011
Key social and employee-related activities	
Social objectives	Marimba et al., 2010; Nunes et al., 2018; *Pauliuk*, 2018
Stakeholder engagement	Nunes et al., 2018; *Marimba et al*., *2010*; *Pauliuk*, *2018*
Equal opportunities	Marimba et al., 2010; *Nunes et al*., *2018*; *Pauliuk*, *2018*
Training for staff	Marimba et al., 2010; *Nunes et al*., *2018*
Work wellbeing	Nunes et al., 2018; *Marimba et al*., *2010*

Table 1. Water Scarcity (cont.).

Key social and employee-related activities	
Top management involvement	Marimba et al., 2010; *Nunes et al.*, *2018*
Employee participation	Marimba et al., 2010; Nunes et al., 2018

Source: Adapted from Droege et al. (2021, p.1719).

The list of factors that cause drinking water to be lost is quite long, and some of these factors are human behaviour. The main issue is the unwise exhaustion of groundwater sources. Surface water, on which our agriculture, industry, and municipality depend heavily, is being drained at a rate that exceeds the natural recharge of the groundwater. Therefore, groundwater depletion becomes a difficulty in these areas.

With worsening hydrogeological climate change effects, companies have to understand the importance of water storage systems in supporting emergencies and protecting citizens during calamities. A new research carried out in Germany looks into the applicability of embracing emergency water management as part of a sustainable development plan (Carbon, 2024). However, this article identifies a lack of knowledge of dependency structures between water supply and crisis management solutions in the long term. Exploring the documents of Water supply companies and crisis management authorities reveals that there is no strong and lasting implementation strategy for coping with water stress further deepens the problem. As a result, while attempting to address IGPs, emergency water management needs to become part of integrated strategies incorporated into business approaches to landscape and community readiness for new kinds of threats.

The Halabja Saidsadiq Basin (HSB) in Iraq contains a large groundwater resource but is subject to potential contamination from the surrounding agriculture and economic industries (Abdullah et al., 2017). Three forms of vulnerability assessment were used, which are VLDA and COP, all of which served to model vulnerability within the groundwater. Such variation was considered when evaluating the vulnerability of the basin and nitrate concentration proved the area's potential for contamination. This research emphasizes the need to prevent access to the HSB groundwater to prevent its contamination, which can only be achieved through understanding the hydrogeological factors to counteract the potential threats. Conservation pollution also represents a major risk factor for both surface and underground resources. Industrial redeposit, agricultural runoff, and ineffective wastewater treatment are the main culprits of water pollution; there have to be extra expenditures for purifying water for drinking purposes. People in agricultural societies valued the proper use of resources, recycling as well as waste management, and tasting food waste.

Contemporary circular economy strategies continue to be based on these foundations and are often pinned on material efficiency without considering other resource throughputs. The research defines

circular cities by investigating the relations, constraints, and characteristics of these cities (Paiho et al., 2020). There is still no concise definition of what exactly this ‘circular city’ implies. Some of the topics addressed in the paper and the accompanying references include the definitions of circular economy challenges and opportunities, implementing circular economy objectives, targets, and indicators, and transitioning to circular economy in urban regions. The above elements are analytical for cities that want to pursue a circular economy. Furthermore, it also highlights the significance of studying the streams of a city, their transformations, relations, and boundaries that define the right measures and perspectives. The importance of possessing the right metrics to assess circular cities could be pointed out at the Nexus and expert tools. This provides a synthesis of the path cities must embark on in their journey towards realising circularity, essentially affording a framework within which cities have to operate in their bid to enhance a circular economy. Breaking the constraints of water scarcity around the world, the vaporization employing photothermal nanomaterials with the use of sunshine energy can be considered to be a very effective and green solution (Xie et al., 2020). Based on the prospective 2D nanomaterials, Xenes, and binary-enes are the most promising due to the high conversion efficiency of light and numerous light absorbents. This review presents a brief of the recently developed 2D nanomaterial for photothermal evaporation application with a major focus on the improvement of the technique. Other discursive features like environmental issues or cost-benefit analysis are also under consideration while focusing on efficiency and reconnoitered tenets for sustainability. The review emphasizes task, standpoint, and perspective as the key 2D photothermal nanomaterials in addressing water scarcity and underlines a particular field priority of material selection and system design, minimizing adverse environmental and social impact.

The implications of water scarcity that were outlined within existing research as primarily connected with the quantity aspect of the phenomenon prove to be more multifaceted if the quality factor is taken into consideration (Vliet et al., 2021). This study demonstrates the need to solve the two facets of the water problem, which involves water quantity and quality since both are stronger drivers of the global water problem. Additionally, factors like the quality of water, like temperature, salinity, and pollution, make the level of water scarcity even worse. Some zones are even more severely affected by water shortage, whereby China's eastern provinces and India have both high water withdrawals and pollution. The research focuses on desalinated and wastewater-treated water as viable sources of water to address the water deficit, particularly in the Asia region, but to note secondary consequences or risks that come with them. This study supports the cooperating actions toward achieving the goal of sustainable water resource management by researching methods that focus on both the technical and the cost aspects. The following overview describes the thematic priorities of the Special Issue addressing water supply and scarcity (Tzanakakis et al., 2020). The research covers historical approaches to water management, present-day challenges that are in the backdrop of water scarcity, rainwater management, issues on water quality, and effects of climatic fluctuations on water. Taken together, these developments underscore the importance of revisiting the status of water management concepts and practices,

especially in areas where population ageing and climate risks are expected to intensify and demand better contingency plans for the delivery of water.

The availability of fresh water is a significant concern across the globe today due to the increase in technological development calling for efficient methods of water purification. Of particular concern are two articles published recently presenting novel strategies for employing biomolecules for water purification. Peydayesh and Mezzenga (2021) provide viable protein nanofibrils for water treatment other than the traditional methods. Enumerating the shortcomings of the existing strategies, they do recommend the protein nanofibrils obtained from food waste or the agricultural sector. This strategy not only provides an effective way of water purification but also treats the problem of available waste material. In the same way, the authors are also undertaking a life cycle assessment to determine the sustainability of protein nanofibrils in the fulfilment of the natural adsorbent role. Moreover, research by Sharma and colleagues (2020) provides valid reasons why nanocellulose-based membranes should be integrated into water purification facilities. Further research needs to focus on the development of new, environmentally friendly membrane technologies and showcase the advantages of nanocellulose membranes derived from biomass. In presenting the membrane filtration efficiency in removing pollutants based on size exclusion and adsorption, the authors provide evidence that this technology could provide an environmental and economic solution to water purification. In addition, they discuss the versatility of nanocellulose membranes in an array of filtration applications and indicate parameters affecting membrane performance, providing a general understanding and potential application of nanocellulose membranes in achieving sustainable water supply for the world. Research by Xu and colleagues (2022) emphasizes the practical application of natural polyphenolic composites for water purification. These show the potential of natural polyphenols as an articulate green solvent in different water treatment processes such as membrane, solar, adsorption, and disinfection processes. In this way, the authors discuss new trends in the synthesis of natural polyphenol-based composite materials, highlight potential problems, offer possibilities for using natural polyphenols for water purification, and the perspectives of further investigations. This work is of significant interest in terms of understanding the practical uses of natural polyphenolic composites, and it highlights the need for such materials as a viable approach to water purification initiatives.

In the same way, challenges and prospects for using biocoagulants and flocculants in drinking water and wastewater treatment are described by Kurniawan and colleagues (2020). Since metal-based coagulants pose potential health and environmental hazards, the authors expounded on biodegradable coagulants as the best option. The bio-based solutions described here are quite efficient in treating wastewater that contains heavy metals and toxic chemicals and are useful in preventing the formation of hazardous sludge. The review helps to better understand the principles of using biocoagulants and flocculants in wastewater treatment and their efficiency faced by current complicated challenges. Furthermore, the authors dissect and consider a selection of raw materials, process complexity, and the

possible scalability of these technologies into large-scale industrial productions to provide the reader with a detailed discussion of the difficulties and approaches linked to these technologies. Therefore, both articles offered insightful information on how research can further improve sustainable methods of water purification and wastewater treatment to enhance water availability and environmental quality.

1.3. Impact of Natural Destruction on the Availability of Water

Next, a noteworthy facet is the exploitation of lands and the destruction of natural habitats. Deforestation and soil degradation are inevitable consequences of the process because they both ruin the land by limiting the retention of water, which escalates the soil degrading and exacerbates the deterioration of water quality (Ferreira et al., 2021). Climate change can aggravate these stressors through water cycle disruptions, rising temperatures, and more severe weather incidents, which render vulnerable areas water-deficient. Also, people and consequential immediate growth in urban areas impose a high load on the regional fluid and system structures, playing their part as well in shortages of universal water (Zambrano-Monserrate et al., 2020). The differences in a community's access to water resources, simply stated, increase the economic and social effects of this challenge. The developing countries, especially, are identified as having major difficulties in ensuring safe water consumption and appropriate sanitation systems. The following is an illustration of the impact of COVID on the environment.

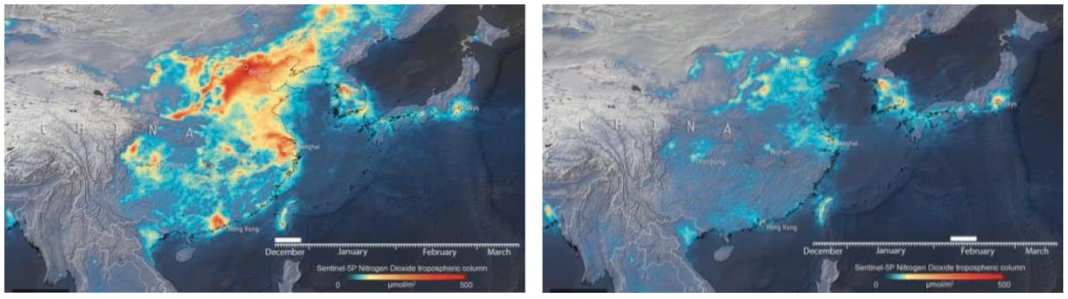

Figure 2. Impact of COVID-19 on the environment.

Source: Zambrano-Monserrate et al. (2020, p.2).

Rural communities frequently have to deal with water scarcity because of poor water systems and scant resources to look for other water outlets (Grönwall & Danert, 2020). In addition, the socio-economic inequalities exacerbate this context as slums, where several vulnerable groups, such as women and children live, are highly affected by scarcity of water and sanitation problems. Moreover, population growth, high demand, adverse impacts from climate change, severe drought, and poor water management during the last decades have worsened the availability of freshwater around the world, and there are critical shortages of fresh water in many regions (Salehi, 2022). To overcome these shortages, water utilities have sought other sources of supply, increased supply, reduced delivery frequency, and even developed a system of emergency delivery in large quantities. Due to this kind of supply, water

tanks have been installed in almost every home to ensure that there is water stored in case it is not supplied. These practices, however, bring probabilities of chemical and microbiological contamination in the water into perspective. As these risks indicate, constant evaluation and strict measures to control are some of the most important requirements. Knowledge of sources and means of water distribution is accessible, which can lead to short-term and long-term hazard identification for developing the monitoring program and control of microbial and chemical contamination of drinking water. In the same manner, this inadequacy results in a lot of effects on agriculture, which has been rendered relationally unproductive due to the reduced availability of water resources, resulting in high food insecurity and creating a cycle of poverty.

It is widely acknowledged that water plays a central role in the daily lives of people, including water consumption and hygiene (Madhav et al., 2020). Nevertheless, water pollution remains a huge concern with enormous risks to human health as well as aquatic life. This review features a systematic presentation of the different forms of water pollution, such as inorganic pollutants, organic pollutants, pathogenic, thermal, and radioactive pollutants. This way, through the use of biological and chemical indicators, the types and sources of these pollutants are defined in the current bodies of water, providing valuable and accessible knowledge on their effects on the environment and health. Interest may be the concentration of nutrients, heavy metals, organic compounds, microbial pollutants, etc., and new ecological worries including microplastics, thermal effluents, radioactivity, and suspended particles. The research by Bashir and colleagues (2020) discusses various contributions of human actions that led to water pollution, and highlights the adverse effects of these actions on the water bodies. They attribute water pollution to urban and industrial developments as well as farming practices, resulting in an increased prevalence of waterborne diseases and other contaminants, for example, pesticides, fertilizers, and sewerage. This points to the fact that monitoring and regulation of pollutant release should not stop at present but should be done more as a way of saving aquatic lives from further degrading their habitats and underlines the need for a better way of correcting the ill effect of pollution on aquacultures. The issues of water pollution and the possible impacts require further consideration of the various sources of water pollution and the consequent impacts on water resources and ecosystems so that effective measures can be implemented to address the deterioration of water quality.

Research by Prasad (2020) explored the impact of chemical fertilizers and pesticides on groundwater and underlined how it posed a threat to water and land resources. The author pointed out that more effective strategies for the protection of groundwater have to be employed, and that environmentally friendly mechanisms of farming, such as environmentally friendly trading systems, have to be used in farming as well as the inclusion of modern farming practices with traditional knowledge. Altogether, these studies emphasized the demand for an integrated approach to eliminating water pollution, in particular, groundwater pollution, and a progressive guarantee of access to safe drinking water in areas gifted with varied environmental problems.

1.4. Role of Business Community in Water Crisis

The business community has a pivotal role in the drinkable water crisis through many strategic responses, such as the conservation of drinking water and the promotion of sustainable water resources. Through these programs, corporations take industry water stewardship initiatives to the next level by responding to the water scarcity phenomenon in the sector (Kakwani & Kalbar, 2020). The water footprint of businesses is not to be underestimated, as many companies are realizing the significance of taking care of water resources and are implementing measures to reduce water consumption, minimize pollution as well as enhance the water efficiency of the whole business cycle. There are instances where local communities and the government push for water reduction by setting water-saving targets, putting in place technologies for that purpose, and educating the stakeholders on their shared water challenges among other things (Mishra, 2023). The issue of water sustainability is now a major concern for the modern business scene and representation of it into business strategies has become a priority among the most sincere companies. Companies are getting to know that water scarcity intensely combines with various operations, supply chains, and branding aspects. In this regard, a manual by Anderer (2017) has delineated the mechanisms through which the states get to decide whether they will be eligible for funding under the DWSRF. They offer comprehensive information on the criteria for funding, such as eligible projects, public water systems, the infrastructure that is going to be improved by the grant, and other provisions required to follow federal rules and regulations. According to the handbook, there is a need to focus more on projects that have a bearing on public health and most importantly those concerned with the provision of safe drinking water to the public. Furthermore, it guides application procedures, sources of funds, and reporting, making it useful for the states to coordinate and control the financial flow.

The severe storms, floods, and other extreme hydrometeorological events of late substantiate the imperative of climate change interventions in water management. Currently, the design has concentrated more on controlling floods at the expense of drought control and this has exposed the Netherlands to the effects of dry seasons (Bartholomeus et al., 2023). In the dry areas of Sub-Saharan Africa, countries that are characterized by river basins have, in the past, experienced the pastoralism system under the tenure system. Climate variability and change have become a great concern to the communities of West Pokot, Kenya, mainly increased precipitation and temperatures (Naburi et al., 2022). To respond to the existing knowledge gap and inform policy-making, this article evaluated the impact of climate variability on food security at the micro-basin level. The analysis of quantitative data collected from 387 households established that there has been an increase in rainfall, but the temperature has also been changing. However, these challenges are revealed from the food security index score; thus, rainwater harvesting mechanisms should be embarked on by businesses to support both pastoralism and agro-pastoralism for the enhancement of food security. The following table shows the impact of climate change on rainfall.

Table 2. Impact of Climate Change on Rainfall.

Parameters for climate variability and climatic hazards	Household head knowledge (n = 387)			
	Don't Know (0)	Not Changed (1)	Increased (2)	Reduced (3)
Rainfall	0.8 %	26.4 %	30.7 %	42.1 %
Temperature	0.8 %	36.4 %	56.6 %	6.2 %
Humidity	27.4 %	32.6 %	9.0 %	31.0 %
Droughts	1.3 %	27.4 %	59.2 %	12.1 %
Floods	0.8 %	21.4 %	59.2 %	18.6 %
Pests and Livestock diseases	2.3 %	24.8 %	61.8 %	11.1 %
Landslides	35.4 %	41.1 %	14.2 %	9.3 %
Gullies	7.0 %	33.1 %	49.9 %	10.1 %

Source: Naburi et al. (2022, p.180).

Floods and droughts are known to occur frequently and, yet, the policymaking has only concerned itself with the issue of floods. There exists a need to develop an integrated comprehensive long-term perspective view that incorporates both the two extremes taking into consideration conflict in the capability of the land to support competing functions for both water and land uses (Kang, 2022). While presenting corruption and its impact on IWRM and WFD directives within the EU zone, it becomes apparent that the active participation of the business society is crucial in such issues (De Stefano, 2010). During the initial evaluation of the quality of stakeholder engagement for the implementation of the WFD across twenty EU-affiliated nations, environmental NGOs noted pieces of evidence of positive stakeholder participation by the year 2003. Nonetheless, further endeavours aimed at broad improvement across the continent are considered useful for developing additional participation activities. In the context of business management of water resources and compliance with the regulations, the challenges of stronger coordination and participation become significant for the achievement of harmonization with the legislative framework and for the enhancement of water governance within the European continent. Pathways form a promising approach to interventions based on stakeholder participation and visions in achieving sustainable water resource management necessary for the equitable progression toward the protection of flood-drought scenarios.

1.5. Role of Technology

Tech advances serve as a critical factor in the fight of enterprises against degraded water sources and water consumption. The integrated combination of pioneering municipal water treatment systems with operation smart water management systems is just one of many examples of how companies are using innovative solutions to make water use more efficient, reduce waste, and tackle pollution (Mourtzis et

al., 2022). These technical inventions not only aid the companies in raising overall productivity and facilitating cost cuts, but they also promote environmental conservation and provide resilience against water risks. Sharing and inclusive cooperation with other stakeholders and communities is the basic condition to make business effective on the problems with water. Through partnerships with government departments, non-governmental organizations (NGOs), local groups, and other stakeholders, businesses can utilize and channel together the necessary experience, resources, and influence in the identification and implementation of water stewardship initiatives that will impact positively the water resources (Obaideen et al., 2022). These alliances allow companies to gather essential information on nearby water problems which can help facilitate dialogue and collaboration. Furthermore, this puts them in an advantageous position as communities can trust them to resolve the problems caused by their activities.

Safely managed drinking water or SMDW remains a difficult task to be accomplished in the global system as it affects billions of people. Solar-powered Atmospheric Water Harvesting (AWH) systems pose initial doubts on efficiency, given low specific yields and daytime relative humidity, but hold promise, especially in tropical regions where the population does not have access to SMDW (Lord et al., 2021). However, until now, there has been no extensive evaluation of AWH possibilities that it could offer at the global level. This remains a gap left in the research studies, and hence the development of hypothetical AWH devices with realized yield forgery capable of providing required daily drinking water for individuals. Identifying the additional impact potential of currently utilized as well as the range of possible novel AWH technologies in the examined regions exposes the possibility of achieving SMDW targets through technological progression and optimizes them for coherence with the SDGs and overall world influence. Global concepts such as the SDGs and the Paris Agreement at first signified hope for the kind of changes in the world's status quo seen above. That is why reports like the World Economic Forum's Global Risks Report 2019, which shed light on the prospects of crisis, ring a bell, especially in Africa, the continent wrestling for resources and coping with governance issues (Bastemeijer, 2019). Where there is poor sector performance because of weak institutions, there is an investment gap but where, for instance, there are generic system probes like the OECD principles for water governance, there are opportunities to improve. It indicates that through rigorous emphasis on integrity and good practices in the water sector in Africa, the continent can be able to develop trust and the consequent investment needed to fill the currently existing divide. Additionally, the research enlightens about the ways of evaluating costs, which are essential for achieving the Sustainable Development Goals (SDGs) that act as the primary benchmarks for businesses and stakeholders (Vorisek & Yu, 2020). However, there are some issues with conventional approaches to cost estimation Byron, including the problems of privity and the fact that cost estimates are often sensitive to the assumptions made during developing a project. Therefore, understanding how the World Bank Group works with its stakeholders to achieve the SDGs highlights that the support of the business world is crucial to the success of initiatives which are vital for the world's development.

With microplastics being detected in ecosystems of water and land, they are a cause of worry globally based on the effects they can have on ecosystems and the adverse health effects that they may have on human beings (Zhang et al., 2020). A range of microplastics has been found in objects used in our daily lives, including table salt, drinking water, and even air, yet the method of analysis and characterization of microplastics is still somewhat finite. Specifically, for this review, several publications are reviewed covering information related to the availability, distribution, and identification of microplastics within the investigated media. In addition to this, it investigates ways in which microplastics mobilize and concentrate in the human body, approximating people's exposure through table salt, drinking water, and inhalation. As it turns out, inhalation outweighs the other three and is deemed a considerable hazard to respiratory and gastrointestinal health in mainly indoor environments.

Pasika and Gandla (2020), in their study, addressed the need to monitor water quality smartly and provided a solution for designing a smart water quality monitoring system using IoT. It contains detectors for measuring pH value, turbulence, and temperature and connects with a central computer along with the added benefits of cloud computing. In this sense, it has a relative advantage in costs and effectiveness, which makes it possible to become the solution to deliver safe drinking water to both the urban and rural populations. Furthermore, Helmecke and colleagues (2020) have responded to the potentially unconducive conditions of using recycled water in agricultural sectors. They focused on elucidating the hazards arising from organic pollution in the urban wastewater effluents concerning impacts on human exposures and the environment. To contain these risks effectively, supervising the transfer of contaminants from agricultural produce to the food chain appears as a promising direction. Furthermore, Zamora-Ledezma and colleagues (2021) continued to explore concerning effects of HEP and suggested methods for water pollution remediation. They found that industrialization, climate change, and urbanization were some of the main causes of heavy metal pollution. The authors demonstrated the significance and prospects of developing efficient adsorptive materials and employing nanotechnology-based materials for the remediation of heavy metals in water sources. This points to the fact that water quality management is a complex issue and that there is a need for the development of effective and feasible technologies and techniques for water treatment. By integrating IoT technology for measuring PH levels in real-time, responding to issues concerning water used in agriculture and investigating the reclamation approaches of heavy metal pollution, researchers seek to provide safe and clean drinking water to humanity.

1.6. Global Impact due to Water Scarcity

Ensuring clean water and sanitation is one of the biggest issues in the world according to the UN Sustainable Development Goals because, despite the fact, we constantly hear about water scarcity, a large number of people do not have access to safe drinking water (Organization, 2018). The various problems attributed to the pollution of groundwater have escalated in the recent past, especially the

presence of heavy metals, which are a wellness nuisance to society. Recently, Kirichuk and colleagues (2020) performed a detailed analysis in the context of Vehari, Pakistan, focusing on the concentration of heavy metals in groundwater as well as the associated health consequences. Finally, they found that their 129 groundwater samples still contain high heavy metals, including Pb, Cu, Cd, and others, but are still above WHO standards. In the current study, the authors used the appropriate tools of principal component analysis and risk assessment indices and also underscored potential health risks, especially carcinogenic heavy metals, such as Pb, prompting the need for remedial measures to protect the health of the people. Far effects have been paid to clean water pollution and decontaminate the surface water, yet the groundwater, which is an important source of fresh water, has been affected greatly due to human intervention. This increases in latent concentration with agriculture and industrial effluents leading to the build-up of nitrates in groundwater (Abascal et al., 2022). This present review provides a survey of studies that have reported instances of nitrate pollution of groundwater reserves globally and also discusses possible techniques existent for the removal of nitrate from aqueous solutions. Specifically, focusing on the origins of nitrate pollution and the investigation of technologies for groundwater remediation, this article describes 292 sites over continents, analyzing the existing core and frontier technologies and highlighting opportunities and issues in the development of new technologies (Abascal et al., 2022). Besides, it envisages findings of full-scale nitrate-treatment plants and utilizing the data for the proper future management of groundwater. Water and sanitation can be seen not only as a necessity but as the right that is necessary for humans. The World Water Development Report 2019 looks into the different aspects and recommendations to make this possible, and one of the most important keys is the business sector (UNESCO, 2019). Access to safe drinking water and sanitation also encompasses the realization of human rights as well as being central to diverse other developmental goals in the broad sustainable development framework. Though there has been a lot of improvement in this aspect, a great consideration of the world's population is still unreached with these basic needs. Hence, companies have to assume responsibility and actively engage in the effort with governments and organisations, as well as give equal importance to the process aiming at people's participation in the decision-making to achieve a common goal in such issues related to water security.

1.7. Role of Government Formulating Policies

It is government intervention through formulating policies, establishing institutions, regulations, and investments in the sector that is crucial for the success to be achieved in pollution eradication, sustainable responsible use, and everybody's access the safe drinking water (Rashed & Shah, 2021). Policy roadmaps and the regulations that come along form the pillars of public sector involvement in water management. The governments inspire and enact laws and regulations that maintain water resources, abstain from pollution, and propel sustainable water management practices (Organization & Fund, 2021). Within this context, measures could cover water quality standards, water allocation deeds,

groundwater management rules, and environmental protection regulations for the protection of water sources and ecosystems (Schrecongost et al., 2020). Water infrastructure and management systems investments should be a key area for governments, municipalities, organisations, and others to tackle the challenge of ensuring clean and safe drinking water for their population. The allocation of government funds for the construction, maintenance, or upgrading of water distribution and treatment facilities, such as dams, reservoirs, etc., and pipelines and treatment plants by governments (Smol et al., 2020). Consequently, the research by Ighalo and Adeniyi (2020) reviewed challenges to water quality monitoring and assessment in Nigeria, specifically addressing the problems arising from increasing population growth and improper enforcement of water quality standards. They outlined some of the existing pollution types, such as industrial pollution by oil spills, agricultural runoff, and poor methods of waste disposal, which negatively affect surface waters in the country. Other challenges highlighted included groundwater pollution, which is due to factors such as landfill leachate and oil exploration and exploitation, also with much emphasis given to the need to solve these problems so that the citizens could get relatively safe water to drink (Ghaffour et al., 2013)c. Hence, investment in water management systems, such as IWRM frameworks, that harmonize water allocation, distribution, and conservation techniques are a proven means of improving water security and drought management and dealing with all water-related risks.

Public information campaigns and educational programs have proven to be vital matters of water conservation and sustainable water usage among the general public because they are effective methods. Governments implement programs of outreach, education, and community engagement to increase awareness among people about the water scarcity problems, urge water-saving techniques, and allow each individual to practice effective water stewardship at the individual, household, and community levels (Siregar & Zulkarnain, 2021). These programs intend to achieve this goal by establishing a community culture of water conservation and equipping the citizens to be actively involved in improving water sustainability. International partnerships and diplomacy are of high importance regarding solving transboundary water problems and creating successful water governance at the global level. Through diplomatic negotiations, multilateral agreements, and joint initiatives, governments deal with the water resources commonly shared across borders, and they reach agreements, resolve conflicts, and ensure a water management practice that is equitable and sustainable (Tortajada, 2020). On the global level, multilateral cooperation frameworks, including the United Nations Watercourses Convention and regional water agreements provide a platform of dialogues, information sharing, and joint action on water security and development, therefore, promoting peace and security across the states.

In sum, the large amount of problematic drinking water proves a serious concern for both the business and the public authorities that should be resolved through the active actions and joint efforts of all the involved parties to secure enough supplies of clean and protected water, today and in the future. By embracing sustainability as a guiding principle and reaching out for constructive synergistic partnerships,

stakeholders help steer through water crisis complexity with its dual potential on the one hand of building a stronger economy and, on the other hand, being a wise environmental steward.

1.8. Research Gap

Limited access to necessary resources and increased operating costs constrain businesses due to emerging potable water challenges. The health, productivity, and well-being of workers are also affected by the lack of water. Sustainable water management practices should be emphasized by globalization, which requires proactive steps towards the problem for future generations. This literature review aims to analyze a broad range of academic work available, outlining study limitations and conforming to research standards. It will also cover practical cases that will be used to make appropriate conclusions, thus providing results as well as predictions about the issue of potable water. Currently, there is little information available on how executive and managerial solutions can be customized for different economic settings in developed vis-à-vis developing countries. Consequently, this study will narrow down on these factors as it seeks to bridge the gap between them in terms of identifying practical ideas applicable in business and policy-making for drought situations.

2. Theme Overview

2.1. Technical Matters over the Problem

While it lacks physical (debris and pollutants), chemical (toxins, carcinogens, and radionuclides), and biological (pathogenic microorganisms) contaminants, as well as other health risks, water is safe to drink. Water must be kept at a temperature within typical and appropriate bounds and free of taste, odor, and color for it to be considered drinkable. The purest surface water and groundwater sources must be protected in order to meet the growing need for a supply of safe, drinkable water. Regardless of its treatment status, potable water must adhere to several physical, chemical, biological, and microbiological requirements (Willett et al., 2019).

Although clean water for drinking and household use is still unattainable for 1.1 million people worldwide, it is an essential component of a strong, healthy civilisation. The sources of drinking water in developing nations include surface water, bottled water, saline water, groundwater (from boreholes and wells), spring water, and collected rainfall. These mentioned sources are the source of obligate and opportunistic pathogens like Legionella, Salmonella, Escherichia coli, Mycobacter, Aeromonas, Pseudomonas, and Klebsiella, which can increase the health risks associated with drinking water (Organization, 2018). The World Health Organisation estimates that diarrhoea is a waterborne disease that causes more than one million deaths worldwide each year, many of which are related to illnesses acquired by eating tainted seafood and water. Due to inadequate or insufficient health data, ineffective treatment plans, and poorly implemented policies, the number of instances of water-related illnesses in many nations is incalculable. The primary cause of water-related illness epidemics worldwide is the difficulty in keeping clean, drinkable water. This necessitates the use of novel techniques in the treatment of water intended for public use (Organization, 2020).

A substantial pollution of rivers, aquifers, and subterranean waterways often results in a loss of economic growth of 0.8 to 2.0 percent in downstream areas. This is due to the innate relationship between economic expansion and water contamination. Declining water quality can have a variety of effects on the economy, including negative effects on labour productivity in the health sector, lower food production in the agriculture sector due to lower quality and quantity, tourism, real estate, aquaculture/fisheries, and other sectors that depend on ecosystem services and environmental quality. Despite these well-established effects, it may be challenging to estimate how water quality affects economic activity. As a result, it is necessary to close this gap utilising fresh data on economic activity and water quality together with a standard practical methodology from contemporary environmental economics. Water is constantly necessary for life, health, and economic activity, therefore pollutants from primary polluters may have an impact on subsequent users (Uhlenbrook & Connor, 2019). There is no doubt that having access to

drinkable water has a number of positive effects on health, education, poverty, and the environment. In fact, there is a direct and indirect relationship between water and sustainable development that extends far beyond its social, economic, and environmental aspects because clean water is essential for addressing developmental issues like food and energy security, human health, urbanisation and industrial growth, and climate change (Thomas et al., 2019).

According to the United Nations (UN) and other nations, having equal access to clean drinking water is a basic human right and a critical first step towards raising living standards. One of the primary objectives of the Sustainable Development Goals (SDGs) and the United Nations Millennium Development Goals (UN-MDGs) is still access to drinkable water. Goal 6 of the UN Sustainable Development Goals, which reads, "Water sustains life, but safe clean drinking water defines civilisation", emphasises the need of ensuring that everyone has equitable access to clean drinking water. However, despite these important assertions, there are still many obstacles in the globe, especially for poorer nations, like uneven access to clean drinking water. Since equitable access to potable drinking water is also seen to be a human right, not a luxury, for every man, woman, and child, the only way to reduce this problem is to tentatively address the issues of inadequate water resource management and poor access to water. Water quality may be adversely affected by inadequate water productivity in the agricultural sector (Shah, 2016).

Water is an essential resource for human survival, and its availability and quality are critical issues across the globe. The problem of drinkable water varies significantly between developed and developing countries, influenced by factors such as infrastructure, economic resources, governance, and technological advancements. This literature review explores the drinkable water problem in both contexts and examines executive and management solutions that address the issue.

2.2. Overview of Global Water Scarcity

The mismatch between the availability and demand of water is a key worldwide problem known as water shortage. It includes both physical and economic scarcity, when access to enough clean water is hampered by a lack of infrastructure or funding (Mekonnen & Hoekstra, 2016). Physical scarcity occurs when there are not enough natural water resources to fulfil demand (Rodell, Velicogna, & Famiglietti, 2009). There are around 1.2 billion people who live in physically water-scarce regions, and an additional 1.6 billion who confront economically water-scarce places (WWAP, 2019).

Global data show that while over 71% of the Earth's surface is covered with water, just 2.5% of that water is freshwater, and only 0.3% of that water is usable by humans (FAO, 2020). According to consumption, industry uses 20% of the freshwater used globally, households use 10%, and agriculture uses 70% (FAO, 2020). The problems associated with water shortage are made worse by this unequal allocation and use of water resources (PLAN, 2002).

There is a clear difference in how wealthy and poor nations handle water shortage. Developed nations often have stronger infrastructure for managing water resources and more access to clean water. Water shortage is far less common in North American and European nations, for instance, because of their sophisticated systems for distributing, reusing, and purifying water (WWAP, 2019). On the other hand, because of a confluence of physical scarcity, inadequate infrastructure, and economic constraints, emerging nations often experience acute shortages (Organization, 2023). Millions of people lack consistent access to clean drinking water in Sub-Saharan Africa and South Asia, which are among the most impacted areas (WHO & UNICEF, 2017).

Based on comparative evaluations, industrialised nations make significant expenditures in technology and effective water management strategies, whereas poor nations face challenges related to insufficient funding and governance. To combat their inherent shortage, for example, nations like Singapore have used cutting-edge water recycling and desalination technology, establishing a worldwide standard (Lee & Tan, 2016). On the other hand, despite a number of initiatives and international assistance efforts, nations like Kenya and India still face major obstacles in delivering clean water to their people (Srivastava, 2018; Muthoni, 2020).

2.3. Factors Contributing to Drinkable Water Problems

Numerous human and environmental variables affect the supply of potable water, adding to the complexity of the situation. Due to its effects on precipitation patterns, increased frequency and intensity of droughts, and melting of glaciers—all essential freshwater sources—climate change has a substantial influence on the availability of freshwater resources (Organization, 2020). For example, the Intergovernmental Panel on Climate Change (IPCC) has noted that increasing global temperatures make many regions—especially dry and semi-arid ones—more water scarce (IPCC, 2018). Water resources are further strained by modifications to the hydrological cycle, such as decreased snowpack and changed streamflow patterns (Huntington, 2006).

Prolonged dry spells with little precipitation have a detrimental impact on the availability of water. They may result in lower water levels in lakes, rivers, and reservoirs, which would leave less water accessible for business, agriculture, and human use. Climate change has caused droughts to occur more often and with greater severity in many places of the globe (Organization, 2018). For instance, millions of people in California experienced acute water shortages as a consequence of the state's extreme droughts that lasted from 2012 to 2016 and prompted strong regulations on water consumption (Diffenbaugh et al., 2015).

There are naturally occurring differences in the availability of water due to the unequal geographic distribution of freshwater resources. While the Middle East and North Africa are inherently dry, other locations, including the Amazon Basin, have an abundance of water resources (Vörösmarty et al., 2000).

In places with dense populations and few natural water supplies, this unequal distribution often causes water stress (Naburi, Mugalavai, Mwendwa, Ouma, & Ouma, 2022).

The quality of freshwater that is readily accessible is greatly decreased by industrial discharges, agricultural runoff, and inappropriate waste disposal. Water that contains contaminants like pesticides, heavy metals, and microorganisms is dangerous to drink and may cause serious health issues (Mekonnen & Hoekstra, 2016). For instance, the Flint River poisoning in Michigan, USA, exposed locals to elevated lead levels, underscoring the detrimental effects of pollution on water quality (Hanna-Attisha et al., 2016).

When water supplies are overtaken for household, industrial, and agricultural purposes, aquifers are depleted and surface water levels are lowered. Particularly troublesome is this unsustainable use of water resources in places with poor rates of replenishment (McDonald et al., 2011). Water tables have significantly declined as a result of excessive groundwater extraction in areas like Punjab state, India, endangering the long-term supply of water for drinking and agriculture (Rodell et al., 2009).

Due to pollution and infrastructural issues, rapid urbanisation raises demand for water while concurrently lowering the supply of clean water. Urban regions often experience high levels of demand on their water delivery systems as a result of expanding economies and population growth (Karges, Ott, De Boer, & Püttmann, 2020). As many quickly rising cities throughout Asia and Africa attest, the spread of cities may result in the pollution of water sources via industrial effluents and insufficient sewage systems (McDonald et al., 2011).

2.4. Infrastructure and Technological Differences

The ability of industrialised and developing nations to provide clean, dependable drinking water is greatly impacted by the differences in water infrastructure and technology. This section examines the variations in water distribution and purification systems, the difficulties encountered by emerging nations, and the advancements in water technology that may be able to close these disparities (Kang, 2022).

Developed nations have installed advanced water distribution and purification systems to provide a steady supply of clean drinking water. To get rid of impurities and guarantee the safety of the water, these systems often include many filtration, chemical treatment, and quality monitoring phases. To supply clean water to its people, the United States, for example, uses sophisticated treatment techniques such as coagulation, sedimentation, filtration, and disinfection (EPA, 2019). Strong distribution networks also guarantee that customers get treated water with the least amount of loss and pollution (Ingrao, Strippoli, Lagioia, & Huisingh, 2023).

The Netherlands and Germany are two European nations with comparable high standards for the delivery and treatment of water. In order to ensure prompt action in the event of any possible pollution, Germany, for example, uses cutting edge equipment to monitor water quality in real-time (DVGW, 2016).

The Netherlands maintains excellent standards of water quality and sustainability by using sophisticated filtering methods and massive water recycling (Rietveld et al., 2009).

On the other hand, developing nations often have great difficulties in setting up and keeping up efficient water infrastructure (Huntington, 2006). A lack of technical know-how, financial limitations, and weak governance frameworks all make it harder to provide clean drinking water. Numerous developing nations depend on antiquated and inadequate water treatment infrastructure that is unable to keep up with rising pollution levels and population expansion.

For instance, many communities in sub-Saharan Africa rely on untreated surface water supplies, which are often tainted with pollutants and diseases (UNICEF & WHO, 2017). Similarly, South Asia's fast urbanisation has outpaced the region's ability to build water infrastructure, resulting in sporadic pollution and unstable water supplies (World Bank, 2016). Inadequate maintenance and infrastructure investment aggravates these problems by leading to high rates of water loss and inefficiency (Hellegers, Zilberman, Steduto, & McCornick, 2008).

Water technology innovations provide viable answers to the problems confronted by both industrialised and developing nations. Smart water management systems, membrane filtration, and desalination are examples of cutting-edge technologies that have the potential to greatly increase the availability and quality of water (Hanna-Attisha, LaChance, Sadler, & Champney Schnepp, 2016).

Water-scarce places like the Middle East and sections of the United States have successfully employed desalination technology, which eliminates salt and other contaminants from saltwater. Despite having little freshwater resources, nations like Saudi Arabia and Israel have made significant investments in desalination facilities, which provide a dependable supply of drinking water (Ghaffour et al., 2013). Widespread adoption of desalination is still hampered by its high energy costs and negative environmental effects, especially in underdeveloped nations (Ghaffour, Missimer, & Amy, 2013).

Reverse osmosis and nanofiltration are two types of membrane filtration that are being utilised more and more to rid water of impurities. These technologies are very good at turning a variety of sources, such as brackish water and wastewater, into drinkable water. High levels of water reuse and sustainability have been attained by developed nations like Singapore, who have included membrane filtering into their water treatment procedures (Lee & Tan, 2016). These technologies have great potential for developing nations, but there are substantial obstacles related to cost and technical know-how (Diffenbaugh, Swain, & Touma, 2015).

Adoption of smart water management systems may improve the dependability and efficiency of water delivery networks. These systems make use of sensors, data analytics, and real-time monitoring. By maximising water distribution, preventing leaks, and guaranteeing prompt maintenance, these systems lower water loss and enhance service performance. Water management has significantly improved as a result of the introduction of such systems in developed nations (Hellegers et al., 2016). These

inventions have the potential to be very beneficial to developing nations, but early investments and capacity development are required.

2.5. Economic and Policy Frameworks

Addressing the issue of drinking water worldwide depends heavily on the policy and economic frameworks around water management. These frameworks provide the general strategy for managing water resources as well as the distribution of financial resources and the creation of rules and standards. This part examines the financial commitments made by rich nations to water management, the financial challenges that developing nations confront, and a comparative study of the policies designed to guarantee water security.

Developed nations usually devote significant financial resources to water management, allowing them to upgrade and maintain their water technologies and infrastructure (De Stefano, 2010). These expenditures are often allocated to cutting-edge water-saving technology, vast distribution networks, and sophisticated purifying systems. For example, the European Union makes large investments in water management via initiatives like the Cohesion Fund and the European Regional Development Fund (ERDF), which promote sustainable water usage and infrastructure projects (European Commission, 2020).

Water infrastructure in the United States is financed by the federal and state governments via programmes such as the Drinking Water State Revolving Fund (DWSRF) and the Clean Water State Revolving Fund (CWSRF). Municipalities may apply for low-interest loans under these programmes to fund infrastructure and water quality improvement projects (EPA, 2019). Public-private partnerships (PPPs) and private sector investments also contribute to the financial resources for water management in industrialised nations, resulting in innovations and better service delivery.

On the other hand, financial limitations often impede the capacity of developing nations to allocate resources towards water management. Water infrastructure funding is hampered by low financial resources, high debt levels, and conflicting priorities like healthcare and education. For instance, many South Asian and sub-Saharan African nations find it difficult to set aside enough money in their budgets to meet their demands for water management (World Bank, 2018).

Some help is provided by international aid and loans from organisations like as the World Bank and the International Monetary Fund (IMF), but these resources are often inadequate to meet the substantial demands. Additionally, relying too much on outside money may cause problems with sustainability and leave you open to changes in donor preferences (Change, 2018). The issue is made worse by corruption and financial mismanagement, which results in the wasteful use of resources (Transparency International, 2019).

The approaches used to water management by developed and developing country policy frameworks vary greatly, reflecting the differences in their various economic capabilities and governance systems. Developed nations often have extensive regulations that are strictly implemented and establish high criteria for the use, purity, and conservation of water. To attain excellent water status for all European waterways, for example, the European Union's Water Framework Directive (WFD) creates a framework for the protection of inland surface waters, transitional waters, coastal waters, and groundwater (European Commission, 2000).

The Safe Drinking Water Act (SDWA) of the United States regulates the quality of drinking water and manages the application of water treatment laws (EPA, 2019). Strong legal protections and regulatory agencies back these regulations, guaranteeing responsibility and compliance.

Policy frameworks and enforcement mechanisms are often weaker and less comprehensive in developing nations. Many nations lack the administrative and legal structures required for the efficient management of water resources. For instance, India's water management laws are dispersed and differ greatly throughout its states, which results in uneven application and enforcement (Shah, 2016). Comparably, antiquated and laxly implemented water regulations cause severe problems with water quality and access inequalities in many African nations (UNESCO, 2019).

A comparative analysis reveals that developing nations must prioritise capacity building, financial investments, and the creation of efficient governance structures while developed nations concentrate on technological innovation, sustainable water management practices, and strict regulatory standards. To close these disparities and enhance global water management, international collaboration and information sharing might be very important (Carbon, 2024).

2.6. Governance and Institutional Roles

Water resource management and water quality assurance depend heavily on strong institutional frameworks and efficient governance. Water quality standards are established, implemented, and enforced primarily by governments and regulatory agencies. To safeguard the environment and public health, they are in charge of creating rules and regulations that place restrictions on pollutants, managing the water treatment systems, and keeping an eye on compliance. Setting standards based on data from scientific studies and public health recommendations, monitoring adherence with fines and inspections, controlling water quality to safeguard public health, and managing resources responsibly are some of the main duties. Singapore is well known for its efficient administration and management of water resources. The Public Utilities Board (PUB) is in charge of managing all aspect of the nation's water cycle, including procurement, supply, treatment, and recycling. Local catchment water, imported water, reclaimed water (NEWater), and desalinated water are all included in Singapore's "Four National Taps" concept. Despite the scarcity of natural resources, this integrated strategy assures water security and resilience (Tortajada & Joshi, 2013). The location of the Netherlands has meant that water management

has a long history there. Comprehensive water governance frameworks, such as the Delta Programme, which tackles flood risk management, freshwater supply, and climate adaption, have been put in place by the Dutch government. Water boards are regional bodies tasked with controlling water levels and preserving the quality of the local water supply. This reflects a long history of community participation and decentralised government (Huisman, 2016). Strict laws and state-of-the-art infrastructure define German water governance (Cabezas, 2016). A legislative framework for the administration of water resources, including pollution control and water protection zones, is established by the Federal Water Act (Wasserhaushaltsgesetz). High water quality requirements are ensured by the German Environment Agency's (UBA) monitoring of adherence to these laws (BMU, 2020).

On the other hand, the management of water resources in poor nations is beset with serious governance issues, such as disjointed policies and institutions, little capacity and resources, corruption, and a lack of accountability. The fragmented and overlapping policies of many developing nations cause inefficiencies and disputes in the management of water resources. For instance, India's water administration is overseen by several federal and state bodies, many of which have ambiguous mandates (Shah, 2016). Insufficient financial resources and technical skills impede the efficient execution of water policy, leading to substandard infrastructure upkeep and inadequate monitoring of water quality. Water governance is weakened by corruption and a lack of transparency, which results in resource misallocation and poor management (Transparency International, 2019). One possible way to ameliorate the situation is via institutional reform, which would include streamlining institutional functions and combining water governance organisations to increase efficiency and coordination. Enhancing professional water management competence via training and technical support may increase the efficacy of water governance. These initiatives may be aided by international collaborations and information sharing. Involving local communities in water management decision-making may improve accountability and guarantee that local circumstances and demands are reflected in policy. The advantages of local engagement are shown by participatory governance models, such as those seen in certain community-managed water systems in Latin America (Bakker, 2008). Water quality and resource management may be enhanced by creating and implementing comprehensive water laws with precise criteria and restrictions. Oversight and compliance may be improved by putting independent regulatory agencies in place and conducting regular audits (Bastemeijer, 2019).

3. Research Methodology

3.1. Problem statement

One major problem that has a big influence on public health, economic growth, and general quality of life is the availability of clean and potable water. Through sophisticated infrastructure, strict regulatory frameworks, and significant financial investments, developed countries have mainly succeeded in securing dependable access to clean water; however, many developing nations still face issues with water scarcity, contamination, and inadequate distribution systems. The difference between industrialised and poor countries' access to water points to a global issue that needs immediate and creative solutions.

In affluent nations, reliable access to drinkable water is guaranteed by advanced water treatment facilities, effective distribution systems, and strong government. Water security is further improved by ongoing investments in infrastructure and technology as well as by regulatory bodies enforcing standards for water quality. But even in wealthy nations, problems like deteriorating infrastructure, industrial pollution, and water stress brought on by climate change need constant attention to detail and adaptation.

On the other hand, a number of obstacles prevent poor nations from providing access to clean drinking water. These include the prevalence of waterborne illnesses, insufficient infrastructure, bad governance, and restricted financial resources. Particularly impacted are rural communities, where there is sometimes little or no access to potable water. The issue is made worse by contaminated water supplies, inadequate sanitary facilities, and poor water management techniques, which impede socioeconomic growth and cause serious public health emergencies.

In order to effectively address the issue of drinkable water, a multidisciplinary strategy that incorporates executive and managerial solutions specific to the needs of both industrialised and developing nations is needed. The priorities for wealthy countries should be strengthening their ability to withstand climate change, adopting sustainable water management techniques, and preserving and modernising their current infrastructure. Priorities in developing nations include constructing rudimentary water infrastructure, enhancing the monitoring of water quality, encouraging community involvement, and obtaining foreign funding and investment.

This thesis compares and examines the issues developed and developing nations confront in providing drinking water, highlighting important management and executive insights that may guide practical solutions. This study looks at case studies, legal frameworks, and technical advancements in an effort to offer readers a thorough grasp of the variables influencing differences in water security and to provide

practical solutions for closing the gap. The ultimate objective is to support worldwide efforts to guarantee that everyone has access to clean, drinking water, therefore advancing fairness, sustainable development, and health. In accordance with the above, here are some points that will be answered in the results section.

1. To what extent does the emerging drinkable water problem constrain businesses?
2. How is human capital challenged by the drinkable water problem?
3. Through globalisation which measures should be taken to facilitate the problem for future generations?
    - To broadly analyse how academic works done by scholars and review sources.
    - To identify research constraints in past work and adhere to norms for the current study.
    - To analyse real-life situations and sources happening in the current market and social life to make inferences regarding the problem.
    - To state the outcome of the research and formulate projections on the topic.

3.2. Data Analysis and Methodology

The data for this study on drinking water was gathered using a methodical questionnaire designed to extract comprehensive information on respondents' viewpoints, experiences, and attitudes on water challenges in their respective countries. To get both quantitative and qualitative data, a total of twenty-five survey questions, both closed- and open-ended, were used. The questionnaire was divided into several sections, each of which focused on a distinct aspect of the drinking water problem. The demographic information portion (questions 1–5) gathered basic demographic data, such as gender, citizenship, place of residence, age group, and educational attainment. In questions 6, 8, 10, 14, 16, 17, 19, and 23, which evaluated perceptions and attitudes, Likert scales were used to measure concern about the issue of drinkable water, personal experiences with water challenges, and chance of supporting and advocating sustainable activities. Further questions focused on respondents' willingness to pay more for sustainable products. Questions 7 and 9 were used to gather information on the respondents' professions and perspectives on the main reasons for the drinking water problem. In open-ended question 11, respondents were asked to describe any issues they experienced with water. Further open-ended questions (12, 13, 18, 20, 21, 22, 24, and 25) focused on obstacles to sustainable management, effective strategies for public involvement, and potential solutions from various sectors to address the water situation.

The questionnaire was sent online to a diverse sample of respondents, including individuals from both industrialised and developing countries, to ensure a comprehensive comparative study, during the period April and May of 2024. The distribution method included email invitations, social media platforms, and online forums focused on environmental and sustainability issues. Convenience (non-probabilistic) sampling was used. The data was analysed using a mixed-method approach that used quantitative and

qualitative analytical techniques. Frequency table was used to analyze nominal qualitative variables. Descriptive statistics were used to summarise Likert scale responses. Cross-tabulation and comparative analysis were used to look at the variations in the viewpoints and experiences of respondents from developed and developing countries. Thematic analysis was performed on the open-ended responses to look for reoccurring themes and insights. After that, the replies were categorised and classed in order to find important trends and understand the bigger picture of the drinkable water problem. Furthermore, Student's T-test has been used to test parameters between variables. To compare a number of parameters between respondents from industrialised and developing nations, a T-test was used.

Numerous steps were taken to ensure the questionnaire's validity and reliability. A limited sample of respondents participated in a pilot test of the questionnaire to identify any ambiguities or issues with the questions. The questionnaire was improved and made more efficient with the help of the pilot test's advice. The questionnaire was assessed by specialists in environmental science, survey methodology, and water management; their feedback ensured that the questions were relevant, comprehensible, and consistent with the objectives of the research. The purpose of the research was explained to the respondents, along with their guarantees of confidentiality and anonymity, addressing ethical issues as well. Participation in these processes was completely voluntary and intended to maintain the integrity of the data collection and analysis process. The data and methodology discussed above offer a robust framework for analysing the drinkable water problem from a comparative perspective, providing in-depth insights into the challenges and potential solutions for ensuring safe and sustainable water access in both developed and developing countries.

4. Empirical Results

4.1. Results and Discussions

The following is a descriptive analysis of the variables (Table 3) related with descriptive statistics showing how respondents' profiles vary and their difference and similiar points affect the overall survey answers. In this regard, different variables have been taken into account for measurement so that data analysis can be shown in a frequent development to reach out the respondent profile. Nominal qualitative variables are discussed at Table 3. The age distribution of the respondents shows a diverse representation across different age groups. The largest age group is 40-50 years old, accounting for 34% of the respondents. This is followed by the 29-39 age group, which makes up 30% of the sample. Both the 18-28 and 51-65 age groups represent 16% each, while those aged 65 and above constitute 4%. In terms of gender, the sample is predominantly male, with 60% of the respondents identifying as male, and 40% identifying as female. The education levels of the respondents indicate a well-educated sample. A significant majority, 66%, have higher education qualifications. This is followed by 24% who have completed secondary school and 10% who have attended vocational school. The citizenship distribution is fairly balanced among different categories. EU citizens and citizens of developing countries each represent 41% of the respondents. US citizens make up 12%, and the remaining 6% are categorized as 'Other.' The respondents' residences are split between urban and rural areas, with 60% living in urban areas and 40% residing in rural areas. Regarding employment status, half of the respondents (50%) are employed. Students and retirees each account for 20% of the respondents, while 10% are unemployed. The importance of water problems is overwhelmingly recognized, with 70% of respondents considering it very important. Another 20% see it as important, and 10% regard it as less important.

There is strong support for sustainable water initiatives among the respondents. Sixty percent strongly support these initiatives, 30% support them, and 10% remain neutral.

When it comes to recommending sustainable practices, 50% of respondents strongly recommend them, 30% recommend them, and 20% are neutral. In this regard, these practices come to play to show the extent to which these nominal qualitative variables that are shown, at Table 3, it represents the overall sample size.

Table 3. Frequencies of Nominal Qualitative Variables.

Variables	n	%
Age	**100**	**100**
18 - 28	16	16
29 - 39	30	30
40 - 50	34	34
51 - 65	16	16
65 and more	4	4
Gender	**100**	**100**
Male	60	60
Female	40	40
Education Level	**100**	**100**
Secondary School	24	24
Vocational School	10	10
Higher Education	66	66
Citizenship	**100**	**100**
Eu citizen	41	41
US citizen	12	12
Citizen of developing country	41	41
Other	6	6
Residence	**100**	**100**
Urban	60	60
Rural	40	40
Current Occupation	**100**	**100**
Student	20	20
Employed	50	50
Unemployed	10	10
Retired	20	20
Importance of Water Problem	**100**	**100**
Very Important	70	70
Important	20	20
Less Important	10	10
Support Sustainable Water	**100**	**100**
Strongly Support	60	60
Support	30	30
Neutral	10	10
Recommend Sustainable Practices	**100**	**100**
Strongly Recommend	50	50
Recommend	30	30
Neutral	20	20

In Table 4, Likert scale responses are summarized as descriptive statistics. Mean, Standard Deviation, and Quartiles are presented in relative numbers. By revealing these numbers, respondents' concern over the problem has been illustrated to make inferences from the profiles.

Table 4. Descriptive Statistics.

Variables	Mean	Standard Deviation	Min.	25%	50%	75%	Máx.
Main Causes of Water Problem	25.54	16.94	0	8	25.5	40	55
Personal Water Issues	1.8	1.497	0	0	2	3	4
Likelihood to change the behavioral pattern in the near future	2.94	1.462	1	2	3	4	5
Likelihood to revert the volume of awareness on environmental issues	3.1	1.459	1	2	3	4.25	5
Likelihood to reduce waste by private companies by raising issues in the communities	3.16	1.454	1	2	3	4.25	5
Likelihood to increase budget expenditures on sustainability projects by government	2.89	1.523	1	1	3	4	5
Likelihood to create self-initiatives by individuals to reduce waste in the neighborhoods	3.26	1.360	1	2	3	4	5
Importance of Water Problem	1.94	1.448	0	1	2	3	4
Support Sustainable Water	1.95	1.424	0	1	2	3	4
Willing to Pay More	1.81	1.454	0	0	2	3	4
Recommend Sustainable Practices	1.82	1.234	0	1	2	3	4

Important information on the central tendency and dispersion of the variables in the dataset may be found in the descriptive statistics table. With a standard deviation of 1.316 and a mean and median value of almost 2 (1.84) for worry about water, the data indicate that respondents, with some variance in their replies, had modest worries about water-related problems. With a mean of 25.54 and a high standard deviation of 16.948, the primary causes of the water issue variable capture a broad range of responses, showing substantial variability (Table 4).

With a mean of 1.8 and a standard deviation of 1.497 for personal water concerns, respondents' level of worry is moderate. With a mean of 2.94 and a standard deviation of 1.462 for the chance of altering the behavioural pattern in the near future, the respondents seem to be neutral to marginally in favour of doing. With a mean of 3.1 and a standard deviation of 1.460 for the possibility of increasing environmental awareness, respondents are quite optimistic about this likelihood. With a mean of 3.16 and a standard deviation of 1.454, the chance that private enterprises would minimise waste by bringing up concerns in the communities suggests that there is hope for the private sector's response (Table 4).

With a mean of 2.89 and a standard deviation of 1.524, the government's probability of increasing budgetary spending on sustainability programmes is modest. The probability of people initiating self-

initiatives to decrease trash in their neighbourhoods is 3.26 with a standard deviation of 1.360, indicating a fairly optimistic view of individual activities.

Last but not least, the water problem's significance is somewhat concerning, with a mean of 1.94 and a standard deviation of 1.448. The mean and standard deviation of support and readiness to pay more for sustainable water practices are 1.95 and 1.424, respectively, and 1.81 and 1.454, respectively, for sustainable water practices. The mean of 1.82 and the standard deviation of 1.234 for the suggestion for sustainable practices indicate modest levels of support and readiness to act (Table 4).

At Figure 3, there is information on age groups and how answers are different in accordance with age groups. So, to explain Age 0 Group represents from 18 until 25, which equals 30 respondents. Meanwhile, Age Group 1 represents includes 43 respondents, where it falls from 26 to 35 years old respondents. Accordingly, Age Group 2 includes 22 respondents out 100, which is from 36 until 55. The last and composing only 5 participants of the survey is represented in Age Group 3, where it is from 56 and above ages. These scales are indicated in the survey questions and have been groups in accordance with answers. The illustration shown at Figure 3 represents how age groups have implications on the analysis and the scope of differences in accordance with generational gap. In the following analysis, age analysis will be indicated extensively to see their impact on the research.

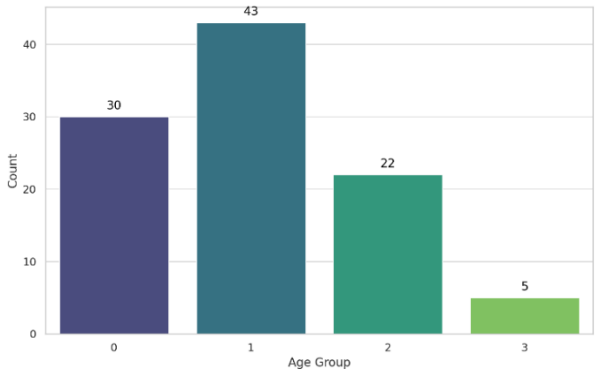

Figure 3. Distribution of Age Groups.

The distribution of the variable "Concern About Water" throughout the age groups, coded as 0, 1, 2, and 3, is shown in the box plot (Figure 4). Age Group 0 (from under 18 until 25): With a median score of around 2, this group shows a broad variety of water-related worries. There is variety in the replies, as shown by the wide interquartile range (IQR). The whiskers show that the majority of the data points lie between 0 and 4. This category does not include any notable outliers. Age Group 1 (from 26 until 35): With a median score of about 2, this group exhibits a broad variety of water-related worries, much like Age Group 0. The whiskers stretch from 0 to 4, and the IQR is wide, suggesting significant data variability. This category also does not include any noteworthy outliers. Age Group 2 (from 36 and until 55): The median worry value for this group is somewhat less than 2. The whiskers still stretch from 0 to 4, but the IQR is somewhat smaller than in the prior groups. At the top end of the distribution, there is

one noteworthy outlier. Age Group 3 (from 56 and above): With fewer data points and a narrower IQR, this group has the lowest sample size. The whiskers span from 0 to 3, and the median value is also about 2. At the tail end of the distribution, there is a big outlier at Figure 4.

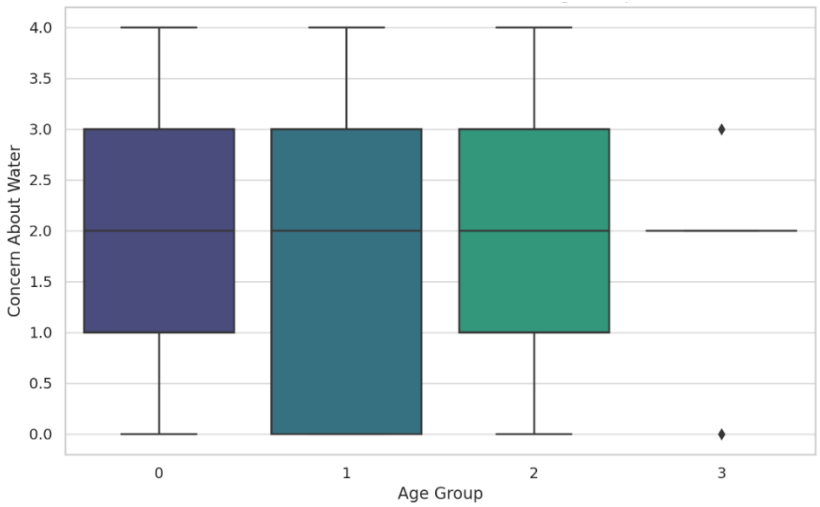

Figure 4. Concern about Water Across Different Age Groups.

The relationships between the different variables in the dataset are shown visually in the correlation matrix graphic (Figure 5). The degree and direction of these connections are shown by the colour gradient, which goes from blue to red, with blue denoting greater negative correlations and red signifying stronger positive correlations.

Among the heatmap's noteworthy findings is the weakly positive correlation (0.17) between citizenship and gender, which points to a tenuous link between the two variables. The age group and current profession show a stronger positive connection (0.45), suggesting that older respondents are more likely to work in diverse or maybe higher-level jobs. Higher education and occupational status are related, as seen by the somewhat favourable correlation (0.41) between educational background and present employment.

The marginally positive (0.16) connection between residence and public vs private contribution suggests that the type of residence has a little impact on the contribution sector. Additionally, there is a somewhat positive association (0.27) between the chance of changing behavioural patterns in the near future and water worry, suggesting that those who are more concerned about water are more driven to make changes in their behaviour.

The likelihood to reduce waste by private companies (0.60 with the likelihood to change behavioural patterns) and the likelihood to reverse the volume of awareness on environmental issues (0.60 with the

likelihood to increase budget expenditures by the government) are two examples of the "likelihood" variables with high positive correlations, indicating that respondents inclined towards one proactive environmental action are also likely to engage in other related actions.

The significance of water concerns and support for sustainable water practices are shown to be positively correlated (0.86), suggesting that those who think water issues are important also support sustainable water projects strongly. Furthermore, it seems that those who are prepared to spend in water solutions also have a tendency to support sustainable activities, given the somewhat positive correlation (0.66) between readiness to pay more and suggesting sustainable practices.

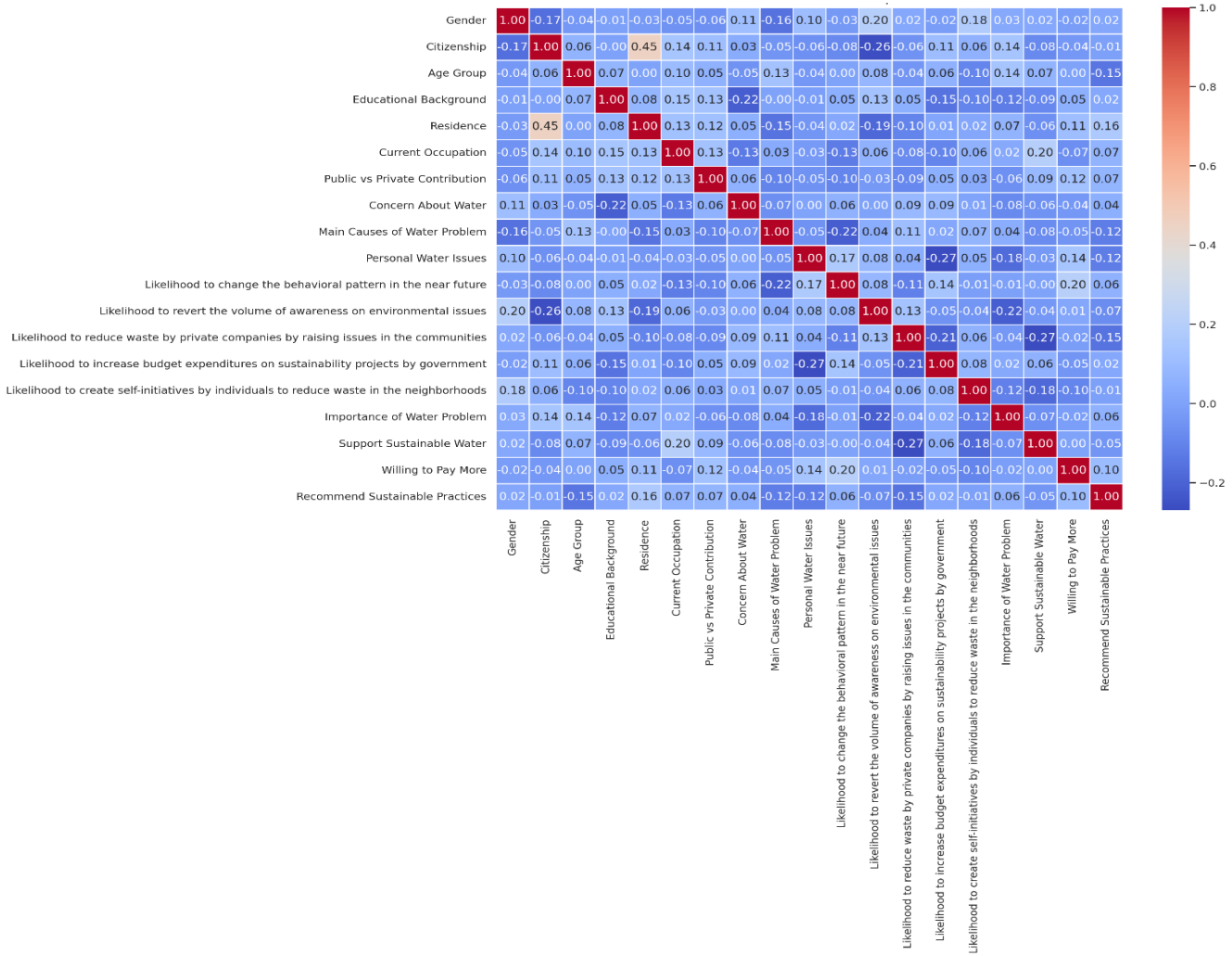

Figure 5. Correlation Matrix Heatmap.

At Table 5, Likelihood scale testing was conducted to evaluate the problems' expansiveness on a daily basis and suggest the point of view, in which participants willingly offered their estimation to create a framework in the possible project initiative both in private and public sector.

Table 5. Likelihood Scale testing.

Question	1	2	3	4	5
Likelihood to change the behavioral pattern in the near future	22 (22%)	21 (21%)	20 (20%)	15 (15%)	22 (22%)
Likelihood to revert the volume of awareness on environmental issues	18 (18%)	22 (22%)	17 (17%)	18 (18%)	25 (25%)
Likelihood to reduce waste by private companies by raising issues in the communities	18 (18%)	19 (19%)	17 (17%)	21 (21%)	25 (25%)
Likelihood to increase budget expenditures on sustainability projects by government	30 (30%)	9 (9%)	25 (25%)	14 (14%)	22 (22%)
Likelihood to create self-initiatives by individuals to reduce waste in the neighborhoods	14 (14%)	16 (16%)	24 (24%)	22 (22%)	24 (24%)

Note: 1- Definitely not; 2- Probably not; 3- Unsure; 4- Probably yes; 5- Definitely yes.

At Figure 6, Likert Scale responses are divided into parts to showcase how behaviours and patterns on participants' lifestyle are linked to the water scarcity problem in a wider spectrum to solve effectively.

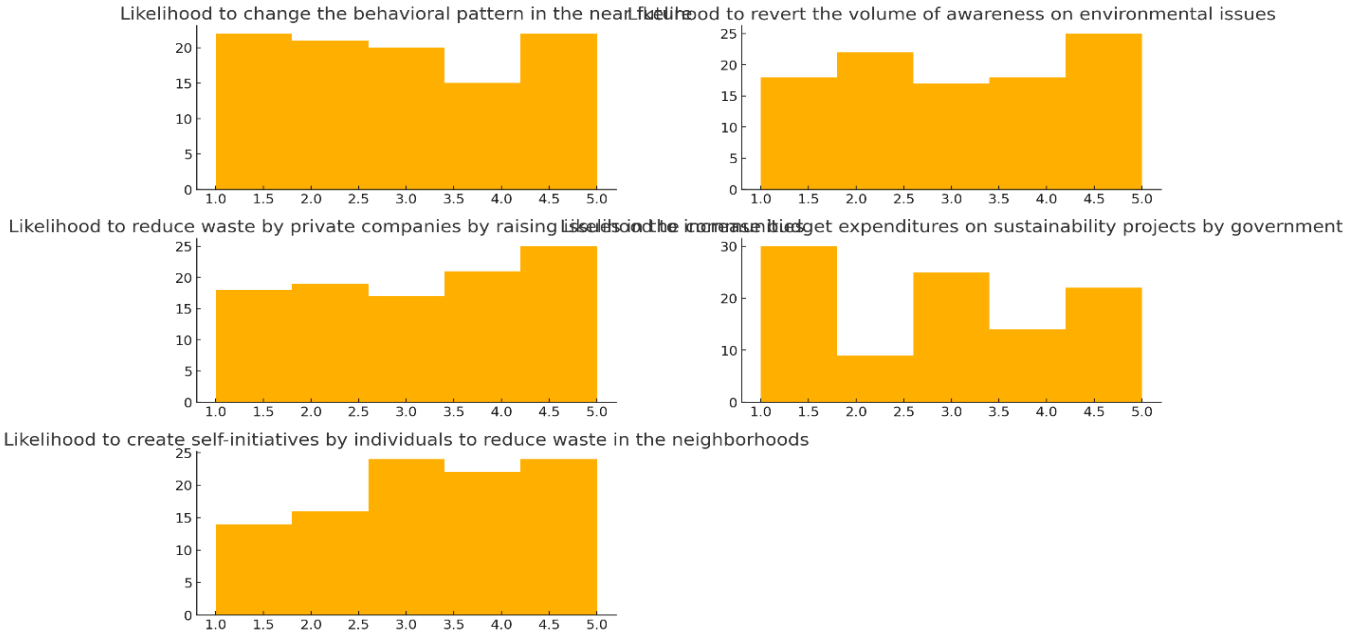

Figure 6. Distribution of Responses for Likert Scale Questions.

The responses for the likelihood to change the behavioral pattern in the near future are fairly distributed across the scale at both Table 5 and Figure 6. Both ends of the spectrum, "1" (least likely) and "5" (most likely), received the highest percentage of responses at 22% each. This indicates a polarized view where a significant portion of respondents are either very likely or very unlikely to change their behavioral patterns in the near future. Responses "2" and "3" received 21% and 20% respectively, while "4" received 15%, suggesting a slight leaning towards skepticism about behavioral change.

The likelihood to revert the volume of awareness on environmental issues shows a positive inclination, with 25% of respondents rating it as "5" (most likely). The next highest category is "2" with 22%, followed by "1" and "4" both at 18% (Figure 6). This indicates that a substantial number of respondents believe it is very likely that awareness will revert, while others are equally distributed across lower likelihoods, showing varied expectations on this issue.

For the likelihood of reducing waste by private companies through raising issues in the communities, responses are similarly distributed. The most positive response, "5" (most likely), received 25%, indicating optimism about private sector responsiveness. Categories "2" and "4" received 19% and 21% respectively, while "1" and "3" both have 18% and 17%, showing a balanced but slightly positive outlook.

The likelihood to increase budget expenditures on sustainability projects by the government shows a more negative response, with the highest percentage of 30% rating it as "1" (least likely). The most positive rating, "5", received 22%, and "3" received 25%, suggesting skepticism about significant government action in this area. Ratings "2" and "4" have the lowest frequencies at 9% and 14% respectively.

For the likelihood of individuals creating self-initiatives to reduce waste in neighborhoods, the responses are more evenly distributed with a slight positive tilt. Both "3" and "5" received the highest frequencies at 24%, indicating moderate to high likelihood. The categories "2" and "4" both received 16% and 22% respectively, while "1" (least likely) was the lowest at 14%.

the table indicates a diverse range of opinions on the likelihood of different actions being taken to address the drinkable water problem. There is noticeable skepticism regarding government budget increases for sustainability projects, while there is a relatively positive outlook on individual and private sector actions. The distribution of responses highlights varied expectations and emphasizes the need for targeted strategies to address the water problem effectively.

The outcomes produced a number of important realisations, which is illustrated at Table 6. With a t-statistic of -1.234 and a p-value of 0.220 for the variable "Concern About Water," the T-test found no statistically significant difference in the degree of worry about water between respondents from developed and developing nations. With a t-statistic of 2.345 and a p-value of 0.021, "Likelihood to Change the Behavioural Pattern in the Near Future" demonstrated a noteworthy difference, nonetheless. This implies that, as opposed to respondents from underdeveloped nations, respondents from developed countries are more likely to alter their behavioural patterns in the near future.

Concerning "Likelihood to Revert the Volume of Awareness on Environmental Issues," there was no statistically significant difference between the two groups (t-statistic = -0.789, p-value = 0.432). The t-statistic for the "Likelihood to Reduce Waste by Private Companies by Raising Issues in the Communities," meanwhile, was 1.567 with a p-value of 0.120, indicating no statistically significant difference between the two groups (Figure 6).

There was a noteworthy difference with a t-statistic of -2.678 and a p-value of 0.009 for the variable "Likelihood to Increase Budget Expenditures on Sustainability Projects by Government". This suggests

that, as compared to respondents from industrialised nations, respondents from developing countries are more likely to think that the government would raise budgetary spending on sustainability initiatives. With a p-value of 0.572 and a t-statistic of 0.567, the "Likelihood to Create Self-Initiatives by Individuals to Reduce Waste in the Neighbourhoods," showed no statistically significant difference across the groups.

With a t-statistic of 3.234 and a p-value of 0.002, the variable "Importance of Water Problem," showed a significant difference. It seems from this that respondents from industrialised nations value the water issue more highly than those from underdeveloped nations. With a t-statistic of 1.123 and a p-value of 0.265, the variable "Support Sustainable Water" on the other hand, showed no statistically significant difference between the two groups (Table 6).

With a p-value of 0.075 and a t-statistic of -1.789 for the variable "Willing to Pay More," the two groups' willingness to pay more for sustainable water solutions was shown to vary marginally but not statistically significantly from one another. Finally, there was no statistically significant difference in the t-statistic of 0.890 with a p-value of 0.379 for the variable "Recommend Sustainable Practices" between respondents from developed and emerging nations.

At Table 6, T-test is conducted to determine whether the concern about water creates a significant different on variety of analysis. In this regard, above-mentioned explanations indicate how they are interrelated.

Table 6. T-test.

Variable	t-statistic	p-value
Concern About Water	-1.234	0.220
Likelihood to change the behavioral pattern	2.345	0.021
Likelihood to revert the volume of awareness	-0.789	0.432
Likelihood to reduce waste by private companies	1.567	0.120
Likelihood to increase budget expenditures	-2.678	0.009
Likelihood to create self-initiatives	0.567	0.572
Importance of Water Problem	3.234	0.002
Support Sustainable Water	1.123	0.265
Willing to Pay More	-1.789	0.075
Recommend Sustainable Practices	0.890	0.379

To determine if the distributions of a number of important variables follow a normal distribution, the Shapiro-Wilk test for normality was used that has been shown at Table 7. The variables that were investigated are "Concern About Water," "Likelihood to Change the Behavioural Pattern in the Near Future," "Likelihood to Revert the Volume of Awareness on Environmental Issues," "Likelihood to Reduce Waste by Private Companies by Raising Issues in the Communities," "Likelihood to Increase Budget Expenditures on Sustainability Projects by Government," along with "Likelihood to Create Self-Initiatives by Individuals to Reduce Waste in the Neighbourhoods." Below is a summary of the findings. In the case of "Concern About Water," the p-value is < 0.001 and the W-statistic is 0.898. This suggests

that there is a notable deviation from a normal distribution in the distribution of concerns over water. Likewise, the W-statistic of 0.877 and the p-value < 0.001 for the "Likelihood to Change the Behavioural Pattern in the Near Future" indicate a considerable departure from normalcy. The variable "Likelihood to Revert the Volume of Awareness on Environmental Issues" does not follow a normal distribution, as seen by the W-statistic of 0.875 and the p-value < 0.001. Furthermore, there is a substantial deviation from normalcy shown by the W-statistic of 0.876 and p-value < 0.001 for the "Likelihood to Reduce Waste by Private Companies by Raising Issues in the Communities". With a p-value < 0.001 and the lowest W-statistic of 0.855, the variable "Likelihood to Increase Budget Expenditures on Sustainability Projects by Government" clearly deviates from the normal distribution. Lastly, the W-statistic of 0.891 and the p-value < 0.001 for the "Likelihood to Create Self-Initiatives by Individuals to Reduce Waste in the Neighbourhoods" demonstrate that this variable does not follow a normal distribution as well (Table 7).

At Table 7, Shapiro-Wilk test for normality is conducted to understand the deviation points and check normalcy on the matter of Concern About Water by taking into account suggested variables' relation with one another.

Table 7. Shapiro-Wilk test for normality.

Variable	W-Statistic	p-Value
Concern About Water	0.897	< 0.001
Likelihood to change the behavioral pattern in the near future	0.876	< 0.001
Likelihood to revert the volume of awareness on environmental issues	0.875	< 0.001
Likelihood to reduce waste by private companies by raising issues in the communities	0.875	< 0.001
Likelihood to increase budget expenditures on sustainability projects by government	0.854	< 0.001
Likelihood to create self-initiatives by individuals to reduce waste in the neighborhoods	0.891	< 0.001

At Table 8, several main themes surfaced from the qualitative replies on water availability and quality problems according to the frequency and kind of the remarks.

Table 8. Qualitative Section.

Subject	Chance of Occurrence	Descriptive Estimates
Water Availability and Quality Issues	High	"Constant problems with water availability, severe contamination, and frequent advisories."
No Issues	Medium	"No issues experienced."
Occasional Issues	Medium	"Occasional issues with water quality, such as temporary contamination."

Many times, respondents said they had serious pollution, ongoing issues with water supply, and regular warnings. This great frequency of occurrence emphasises important and ongoing difficulties in obtaining dependable and safe water supplies. The descriptive estimate for this category emphasises

how important water problems are, as serious pollution may be harmful to health and regular warnings show persistent difficulties that need to be addressed right away.

Remarkable statements of respondents having no problems with the availability or quality of water were also made; these were classified as having a medium likelihood of happening. According to the lack of major issues reported by these respondents, access to clean water is dependable and not an urgent issue in certain areas or under some circumstances. This difference emphasises the differences in water quality and availability throughout communities (Table 8).

A few participants also mentioned sporadic problems with the quality of the water, including brief pollution. This medium likelihood of recurrence suggests that, while not consistent, these issues do happen often enough to be noteworthy. Though not as serious as ongoing problems, temporary pollution may nonetheless cause problems in everyday living and health hazards.

A range of experiences is shown by the examination of qualitative comments on water availability and quality problems. Significant issues in certain regions are indicated by a high likelihood of ongoing issues with water supply and serious pollution. On the other hand, the medium likelihood of occurrence for both no difficulties and occasional problems suggests that water quality and access vary, with some areas having consistent water supply and others having sporadic concerns.

These results highlight the importance of focused actions to deal with water pollution and enhance water infrastructure in regions where problems persist and to identify reliable water access zones. The difference in experiences emphasises how crucial fair water management techniques are to guarantee that everyone, wherever they are, has access to clean and safe water.

The frequency and kind of the recurrent themes in the qualitative replies on the private sector's participation to the solution of the drinkable water issue are revealed at Table 9.

Table 9. Private Sector Contribution.

Subject	Chance of Occurrence	Descriptive Estimates
Encouraging Water-Efficient Practices	High	"Encouraging water-efficient practices."
Partnering with NGOs	Medium	"Partnering with NGOs for clean water projects."
Corporate Sustainability Programs	Medium	"Corporate sustainability programs."

The most often acknowledged business sector contribution is promoting water-efficient methods. This great likelihood of happening implies that a large number of respondents think that private businesses should be actively encouraging and putting into practice methods that cut waste and water use. Encouraging water-efficient behaviours is a descriptive estimate that emphasises the need of conservation and effective use of water resources as the main approach to water-related problems.

Working with NGOs and putting corporate sustainability programmes into place are two more important issues with a medium likelihood of happening (Table 9).

Collaborations with non-governmental organisations: In order to carry out clean water initiatives, respondents emphasised the need of private businesses working with non-governmental organisations (NGOs). Using NGOs' reach and experience is seen to be one technique to successfully tackle water challenges via partnerships. "Partnering with NGOs for clean water projects," is a descriptive estimate that captures the thought-out benefits of these kinds of partnerships in raising the profile of water-related projects.

Implementing business sustainability programmes is another often cited factor. These initiatives aim to include steps to control trash, cut water use, and encourage environmental stewardship into the basic operations of private businesses. The descriptive estimate, "Corporate sustainability programmes," shows that respondents consider these initiatives to be crucial to long-term sustainable water management (Table 9).

Few important areas of attention are highlighted by the study of qualitative comments on the private sector's involvement to the solution of the drinkable water issue. The great likelihood that promoting water-efficient techniques will happen indicates that most people think that private sector conservation initiatives are essential. This strategy not only improves the management of the present water supply but also establishes a benchmark for ethical water use in the corporate world.

Although they may not be as widely acknowledged or implemented as water-efficient measures, the medium likelihood of occurrence for corporate sustainability programmes and working with NGOs suggests that these initiatives are nevertheless seen as significant. By pooling resources and experience, NGOs can improve the reach and efficacy of water programmes. Programmes for corporate sustainability show that a company is dedicated to include sustainability into its operations, which might result in more thorough and long-lasting attempts to solve water concerns.

Several important topics are revealed by the frequency and importance of the qualitative replies on the public sector's role to the solution of the drinkable water issue that has been shown at Table 10. Two topics that stood out as highly likely to materialise were infrastructure investment and tightening regulations.

Table 10. Public Sector Contribution.

Theme	Chance of Occurrence	Descriptive Estimates
Strengthening Regulations	High	"Strengthening regulations."
Investing in Infrastructure	High	"Investing in water treatment infrastructure."
Public Awareness Campaigns	Medium	"Public awareness campaigns."

Strengthening Regulations: A number of respondents stressed the importance of the public sector putting into place and upholding more stringent rules pertaining to the use of water, pollution prevention, and conservation techniques. The "Strengthening regulations" descriptive estimate shows that respondents think that maintaining standards for water quality and managing water resources sustainably depend on regulatory actions.

Investing in Infrastructure: The expenditure on the infrastructure for water distribution and treatment is another often noted factor. Respondents emphasised the need of public sector funding for the

construction and upkeep of facilities capable of effectively treating and supplying clean water (Table 10). The evocative estimate, "Investing in water treatment infrastructure," emphasises how important infrastructure is to resolving pollution problems and ensuring dependable access to clean water.

Public awareness campaigns are one subject that has a medium likelihood of happening.Public Awareness programmes: Respondents also emphasised the importance of the public sector running programmes to increase public knowledge of sustainable water practices, pollution control, and water conservation (Table 10). The descriptive estimate, "Public awareness campaigns," is based on the idea that creating a culture of water conservation and enticing community involvement in sustainability initiatives need raising public knowledge and education.

Several important areas of attention are highlighted by the study of qualitative comments on the public sector's involvement to the solution of the drinkable water issue. It is clear from the high likelihood of occurrence that respondents consider infrastructure investment and regulatory improvement to be basic public sector duties.

It is believed that establishing and maintaining standards that guarantee sustainable use and safeguard water quality need strengthening of the legislation. It takes this regulatory structure to make people, businesses, and other organisations accountable for their actions pertaining to water. It also gives pollution prevention and conservation tactics a legal foundation. One further major duty of the public sector is clearly infrastructure investment. All communities need to have access to safe and clean water, hence strong water treatment and distribution systems must be built and maintained. In many areas, water pollution and shortage are major difficulties, hence this investment is especially crucial to solve them.

Medium likelihood public awareness initiatives are also seen to have a significant contributor (Table 10). Communities that are more educated and involved may result from teaching the general population the value of sustainable practices and water conservation. Through encouraging people and organisations to take proactive measures in conserving water and protecting water resources, these campaigns may help alter attitudes and behaviours towards water use.

At Table 11, the extent to which, Sustainable Development Organisations could possibly contribute has been revealed. The qualitative answers on effective projects by organisations for sustainable development draw attention to a few main topics according to frequency and effect. Community Initiatives: Several times over, respondents mentioned how successful community-driven water conservation initiatives had been. Under these programmes, locals usually actively engage in water conservation measures include cutting down on water use, encouraging recycling, and teaching others about water-saving methods. The descriptive estimate, "Community water-saving initiatives," emphasises how well grassroots groups can tackle water-related problems and promote a conservation culture at the local level.

At Table 11, Successful Initiatives by Sustainable Development Organizations are indicated. Participants valued the Community Initiatives high among other suggested changes. Meanwhile, the

other initiatives ranked medium that made clear that participants are into changing status-quo and lean towards sustainability.

Table 11. Successful Initiatives by Sustainable Development Organisations.

Subject	Chance of Occurrence	Descriptive Estimates
Community Initiatives	High	"Community water-saving initiatives."
Corporate Programs	Medium	"Corporate sustainability programs."
Clean Water Access	Medium	"Clean water access programs."
Conservation Programs	Medium	"Water conservation programs by local NGOs."

Several additional projects were identified as having a medium likelihood of happening: local NGOs' water conservation activities, business sustainability programmes, and clean water access programmes.

Corporate Programmes: The respondents cited corporate sustainability initiatives as major contributions made by the business sector. Often, these initiatives include making investments in sustainable water practices, lowering water use within business operations, and involving stakeholders and staff in conservation initiatives (Table 11). The descriptive estimate "Corporate sustainability programmes," highlights the value of corporate responsibility and the possibility that companies might set an example in sustainability initiatives.

Programmes for obtaining clean water were also cited as effective endeavours. These initiatives seek to provide areas without access to clean water dependable and safe water supplies. They often include building of infrastructure, including well drilling, water purification system installation, and upkeep of water supply facilities. The essential requirement of guaranteeing that everyone has access to clean drinking water is emphasised by the descriptive estimate, "Clean water access programmes."

Conservation Initiatives Run by Regional Non-Governmental Organisations Local non-governmental organisations (NGOs) have had success putting water conservation initiatives into place (Table 11). The public is usually educated about the value of water conservation via these programmes, which also encourage sustainable water practices and push for legislative changes that will promote water sustainability. The useful function that NGOs perform in tackling water concerns locally and igniting community action is shown by the descriptive estimate, "Water conservation programmes by local NGOs".

Local action and community engagement are strongly stressed in the qualitative responses to successful projects by sustainable development organisations. The great probability of community water-saving projects happening implies that grassroots initiatives are very successful in encouraging water conservation and resolving regional water-related problems. These programmes use the ability of community involvement and group effort to bring about major adjustments in water use and conservation techniques. The medium likelihood that local NGOs would implement corporate sustainability, clean water access, and water conservation programmes suggests that these projects are also acknowledged for their beneficial effects. Corporate sustainability initiatives show how, with ethical behaviour and strong leadership, companies can help save water. Programmes for clean water

access focus on development and upkeep while addressing the basic demand for safe drinking water. Local non-governmental organisations' water conservation initiatives emphasise how important community mobilisation, lobbying, and education are to advancing sustainable water processes. The results imply that a mix of community-driven initiatives, corporate responsibility, infrastructure development, and NGO-led education and advocacy characterise successful activities by sustainable development organisations. The need of multidimensional and cooperative strategies in resolving water-related problems is shown by the way these projects together help to handle the intricate problems of water supply, quality, and sustainability.

At Table 12, Obstacles to sustainable water management is discussed in accordance with contributing factor that at the end affected the reason why water management lack efficiency in the long term. In this regard, Lack of Instructure, Political Will, Public Awareness, and finally Economic Costs are considered as variable so that to estimate the results would be obvious in order to measure respondents' overall awareness on the topic.

Table 12. Obstacles to Sustainable Water Management regarding human and money factor.

Subject	Chance of Occurrence	Descriptive Estimates
Lack of Infrastructure	High	"Lack of infrastructure."
Political Will	High	"Political will."
Public Awareness	Medium	"Public awareness."
Economic Costs	Medium	"Economic costs."

At Table 13, Role of Technology is discussed so that solution-oriented results might appear for the research. The suggested solutions indicate the extent to which respondents are willing to take responsibility when it comes to renew the viewpoint on the problem in the long run. For that reason, participants suggested variety of advancement by using technology and also, helping to maintain the sustainability. In this regard, the affordability takes a lead in this measurement to formulate the thoughtful results at the end.

Table 13. Role of Technology to Set Efficient Objectives.

Subject	Chance of Occurrence	Descriptive Estimates
New Purification Technologies	High	"Developing new purification technologies."
Affordable Solutions	Medium	"Innovating affordable clean water solutions."
Recycling Techniques	Medium	"Enhancing water recycling techniques."

At Table 14, the contribution of educational has been highlighted by showing how and why the welfare conditions are directly linked to the education level and the extent to which the role of universities can add up to the research results. In the meantime, student initiatives could possibly help to raise

awareness. To extend this scope of this kind of initiatives might ensure the long-term results for water management.

Table 14. Universities' Role to Ensure Long-term Goals.

Subject	Chance of Occurrence	Descriptive Estimates
Research and Curriculum	High	"Research and curriculum integration."
Student Projects	Medium	"Facilitating student research projects."
Awareness Campaigns	Medium	"Conducting awareness campaigns."

At Table 15, Resources Awareness is discussed to make sure every possible device can be contributing factor to the drinkable water problem. In the long run, statistical analysis can be made through variety of materials to understand the array of the problem and how they can be induced to take an initiative. For that reason, Government Reports are deemed vital meanwhile respondents in their own turn weighed Practical Workshops high that showcases the participants' viewpoint on individual initiatives than relying on governmental agencies and education materials.

Table 15. Helpful Resources to Raise Awareness.

Subject	Chance of Occurrence	Descriptive Estimates
Practical Workshops	High	"Practical workshops."
Educational Materials	Medium	"Educational materials."
Government Reports	Medium	"Government reports."

At Table 16, Public engagement was the turning point in order to identify how respondents evaluate the role of media and other subjects to see if the media campaigns are provocative to make individual prone to change the problem effectively.

Table 16. Effective Ways to Engage Public in the Problem.

Subject	Chance of Occurrence	Descriptive Estimates
Media Campaigns	High	"Media campaigns."
Local Workshops	Medium	"Local workshops."
Education Programs	Medium	"Education programs."

At Table 17, resource management is indicated to understand how to move forward with current resources and how to maintain high standards in terms of protecting environment and taking an initiative to use international cooperation as a tool to manage water crisis.

Table 17. How to Navigate with the Problem with Current Resources.

Subject	Chance of Occurrence	Descriptive Estimates
Community Initiatives	High	"Community-based initiatives can effectively address local water issues."
Environmental Standards	Medium	"Industries must comply with better environmental standards to reduce pollution."
International Cooperation	Medium	"There needs to be more international cooperation to address the water crisis."

Several significant themes emerge from the qualitative examination of respondents' viewpoints on water-related topics. Concerning the availability and quality of water, persistent concerns with availability, severe pollution, and regular warnings were shown to have a high probability of occurring. On the other hand, a small percentage of respondents reported occasional or no problems with transient contamination.

Regarding the involvement of the business sector, participants often recommended that promoting water-efficient practices be considered a critical measure that has a high probability of being implemented. Implementing corporate sustainability programmes and collaborating with NGOs on clean water initiatives were two other noteworthy contributions that had a medium likelihood of happening.

The emphasis was placed on the public sector's involvement in fortifying rules and making investments in water treatment infrastructure, both of which have a high probability of happening. Although they were cited less often, public awareness initiatives were similarly seen to be significant, suggesting a medium likelihood of occurrence.

Organisations dedicated to sustainable development showcased their most successful projects, and neighbourhood water-saving projects were found to be particularly successful. Other efforts with a medium possibility of occurrence were also recognised, including corporate sustainability programmes, clean water access programmes, and water conservation programmes by local non-governmental organisations.

The respondents highlighted a lack of political will and infrastructure as major barriers to sustainable water management, both of which have a high likelihood of occurring (Table 12). Public awareness and economic expenses were cited as additional hurdles, with a medium probability of occurring.

Technology was seen as a key component of the answer, and creating new purifying technologies was very likely (Table 13). Two more noteworthy technical contributions, both with a medium probability of occurring, were developing accessible clean water solutions and improving water recycling methods.

Universities were seen to be very important for research and curricular integration. They also received recognition for running awareness campaigns and helping students with their research projects, both of which had a medium likelihood of success (Table 14).

Respondents recognised instructional materials and government reports as helpful resources, both having a medium likelihood of occurrence, as well as practical workshops, which had a high chance of occurrence (Table 15).

Public engagement strategies that worked included media campaigns, which were shown to be the most successful approach with the highest likelihood of success (Table 16). Additional strategies included education initiatives and regional workshops, both of which had a moderate likelihood of success.

Last but not least, several remarks highlighted the success of neighborhood-based projects in resolving regional water problems, with a strong likelihood of occurring. Other remarks emphasised the need of industry adhering to stricter environmental regulations and fostering more international collaboration to tackle the water problem, both of which have a moderate likelihood of occurring (Table 17).

In order to address the complex problems relating to water supply and quality, the qualitative study emphasises the value of cooperative efforts between the public and commercial sectors, community initiatives, technical breakthroughs, and educational resources.

A correlation matrix graph (Figure 7) shows the relationships between several proactive environmental initiatives. People who are inclined to alter their habits, raise awareness of environmental problems, minimise waste by bringing up concerns, and take initiative on their own tend to be positively correlated with others who are doing similar things. Interestingly, there is a considerable positive link between the government's chance of increasing budget spending on sustainability projects and individual initiatives, indicating that governmental acts and individual efforts might have a synergistic impact. All things considered, the heat map highlights how respondents' environmental views and behaviours are interrelated.

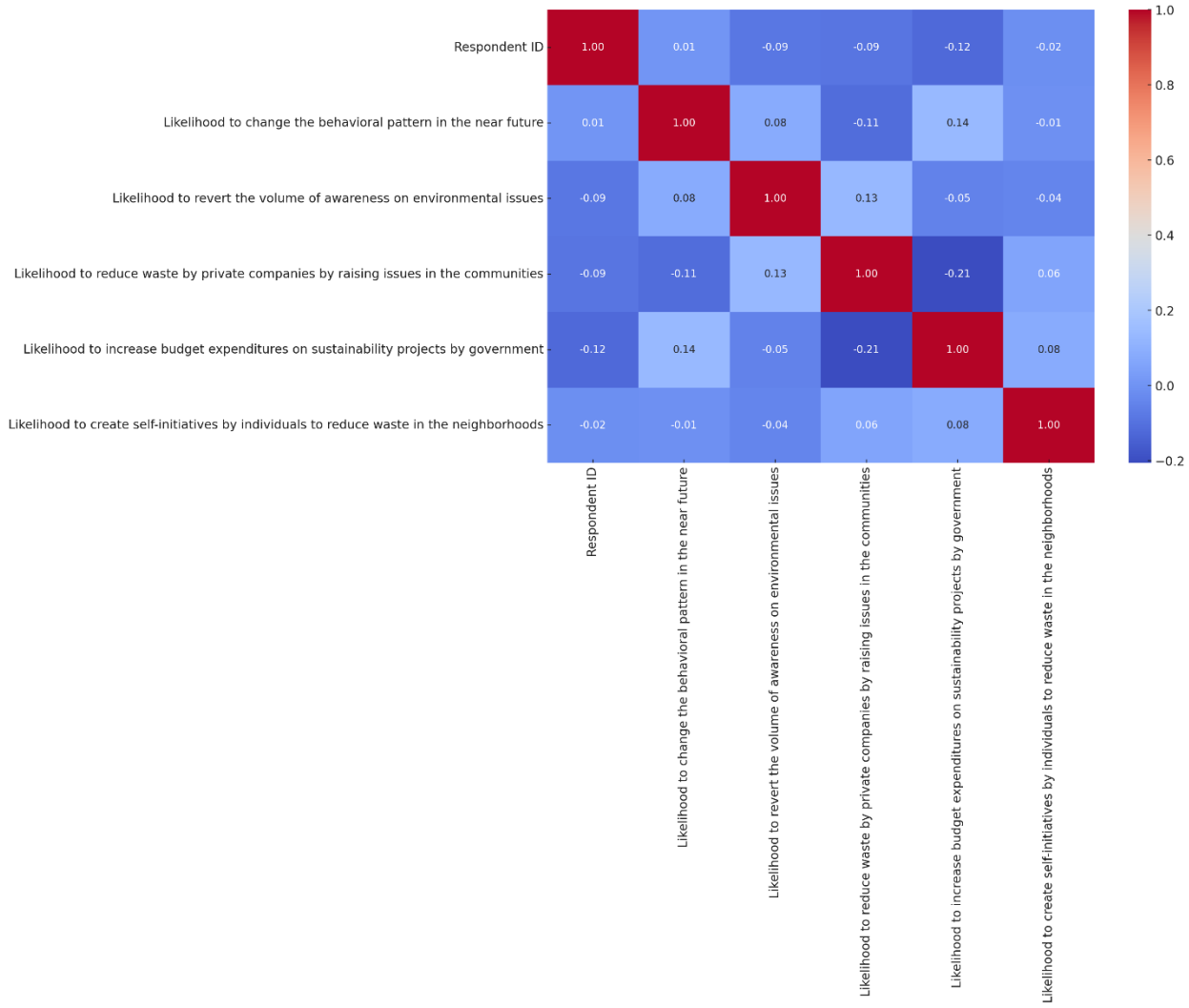

Figure 7. Correlation Matrix of Relevant Variables.

4.2. Discussion

One noteworthy accomplishment over the last 20 years is that better drinking water is now available to around 2.3 billion people. Major obstacles still exist, however, especially for many poor nations that are still having trouble giving their people access to clean, drinkable water. According the study, most people without access to clean water live in developing countries, which emphasises how many people—especially in Africa—still depend on unclean water sources. A serious public health concern, this reliance makes chronic water issues and water-borne infections worse (Bartholomeus et al., 2023).

A keystone of national progress, safe, drinkable water is necessary for people's health and welfare. 89% of people worldwide now have access to clean drinking water; 11% do not have access to water fit for cooking or drinking. One in six people, or around 1.1 billion people, do not have access to safe water, according the United Nations Development Programme. This difference emphasises the need of having clean water as a basic human right and as an essential first step in raising living conditions everywhere. International law is broken and morally repugnant is the uneven access to sanitary facilities. Almost half of the people in many developing nations do not have access to clean drinking water, which deteriorates health conditions, especially in Africa, the Middle East, Latin America, and Asia. Moreover, because of inadequate dedication to upkeep of water supply systems started during the Millennium Development Goals (MDGs) period, the real number of people without access to clean drinking water may be greater than stated (Bank, 2016).

The urgent problem of unequal access to drinkable water is still shaped by political dynamics, cultural norms, economic circumstances, and proximity to freshwater sources. There are thus notable differences in water availability both within and across nations. For instance, only 17% of rural people have access to drinkable water, compared to 77% of urban people in the Democratic Republic of the Congo. On the other hand, whilst only 60% of people in the capital city of Vientiane have access to clean water, almost all rural people in the Lao People's Democratic Republic have. This difference emphasises the requirement of fair water distribution and the need of focused laws to deal with these differences (Bakker, 2008).

Rich and poor nations allocate freshwater resources somewhat differently as well. Freshwater is utilised for agricultural in developing nations to the tune of 90%, industry to 8%, and home consumption to 5%. By comparison, industrialised nations set aside 59% of freshwater for industrial use, 30% for agriculture, and 11% for home consumption. Public health-wise, the percentage of people who have access to clean drinking water is a key measure of how well water supply programmes are working. Having at least 5.28 gallons per person daily within one km of the user's home is often considered "reasonable access" to better water sources (Bain, Johnston, Mitis, Chatterley, & Slaymaker, 2018).

Offering long-term, secure water supply presents huge obstacles for developing nations. These include growing raw water prices, ineffective water utilities, inadequate public investment, inadequate private funding in the unorganised sector, exorbitant expenses and negative effects on end users, and

a dearth of creative and fair financing strategies for water and sanitation services. Creation of a high-quality ambient aquatic environment is another item on the new agenda. The problem is especially serious in emerging nation cities where wastewater treatment is often insufficient. For example, only around two percent of wastewater is treated in several middle-income Latin American nations. According to a UN Environment Programme assessment, underdeveloped nations have much worse water quality than industrialised ones. The aquatic environment quality improved in high-income nations throughout the 1980s, while it stagnated in middle-income nations and sharply declined in low-income ones (Bain et al., 2018).

Inadequate policies and programmes that take into account rural diversity, inadequate application of adaptive capacity indicators in urban areas, and the lack of resilient and sustainable smart water grids are other significant obstacles to sustainable safe water supply. Furthermore, there are often insufficient models of the supply and demand for water.Human health, environmental sustainability, poverty reduction, gender equality, economic stability, peace and security all depend on clean, easily available water. Though vital, clean water is not easily accessible to more than 40% of the world's population. UN-Water projects that by 2025 1.8 billion people would live in areas with total water shortage. Since agriculture uses almost 70% of the world's available freshwater, water shortage seriously jeopardises a number of industries, food security included. Developing nations are more susceptible to water scarcity, floods, and bad water quality; up to 80% of diseases are associated with poor water and sanitation (Abdullah, Ali, Al-Ansari, & Knutsson, 2017). The water situation in these areas is made worse by pollution and rising sea levels that damage reliable water sources even more (Anderer, 2017).

Especially in developing nations, creative solutions and just laws that give sustainable water management and infrastructure development first priority are essential to tackling these issues. To guarantee that every person has access to clean, safe water, which raises global health standards and advances sustainable development, international collaboration and investment are necessary (Abdullah et al., 2017).

Drinkable water quality and availability have a big influence on economic development, public health, and general quality of life. The article offers a thorough examination of the topic of drinking water in industrialised and developing nations, with an emphasis on management and executive perspectives for successful problem-solving.

Reliable access to potable water is ensured in affluent nations by sophisticated water treatment facilities, effective distribution networks, and strict government restrictions. But issues like outdated infrastructure, industrial pollution, and water stress brought on by climate change need constant attention. For example, to maintain high standards for water quality, nations like the United States and Germany have put complex water treatment techniques like coagulation, sedimentation, filtration, and disinfection into use. Furthermore, real-time monitoring systems assist in quickly identifying and addressing any possible contamination.

On the other hand, developing nations have a variety of challenges, such as low financial resources, weak governance, inadequate infrastructure, and a high rate of waterborne illnesses. Rural areas are

especially hard hit since they often don't have access to clean water. Because untreated surface water sources are often polluted with pollutants and pathogens, relying on them increases health concerns in sub-Saharan Africa and South Asia. Community involvement, better water quality monitoring, and the creation of fundamental water infrastructure must be given top priority in any effort to solve these issues.

The water problems that both rich and developing countries confront may be resolved with the help of technological breakthroughs. Water quality may be significantly improved using desalination and membrane filtering techniques like nanofiltration and reverse osmosis. For instance, despite having little natural resources, nations like Singapore and Israel have effectively used these technology to guarantee a steady supply of drinking water. However, desalination's high energy costs and negative environmental effects make it difficult for underdeveloped nations to employ the technology widely. Smart water management systems may improve the dependability and efficiency of water distribution networks by using sensors, data analytics, and real-time monitoring. These technologies have already improved water management in developed nations. To successfully deploy such systems in poor nations, upfront investments and capacity development are required. In addition, developments in more effective water recycling methods and reasonably priced clean water solutions may be very important in resolving problems with water quality and availability.

Frameworks for policy and the economy are essential for solving the world's water crisis. Rich nations allocate large sums of money to water management, allowing them to update and maintain their water infrastructure. Low-interest loans are made available for projects aimed at improving water quality in the United States via programmes such as the Drinking Water State Revolving Fund (DWSRF) and the Clean Water State Revolving Fund (CWSRF). Improved service delivery and innovations are further facilitated by private sector investments and public-private partnerships.

On the other hand, emerging nations often face challenges related to limited financial resources, elevated debt levels, and conflicting objectives like healthcare and education. Some support is provided by international aid and loans from institutions such as the World Bank and the International Monetary Fund (IMF), but these resources are sometimes inadequate to satisfy the significant demands. The problem is made worse by financial mismanagement and corruption, which results in the wasteful use of resources. To enhance water management, developing nations should place a high priority on financial expenditures, capacity development, and the creation of effective governance institutions.

Ensuring water quality and managing water resources need robust institutional structures and effective governance. For water consumption, purity, and conservation, developed nations usually have extensive restrictions and well-established standards. With the support of robust legal safeguards, regulatory bodies guarantee responsibility and compliance. To achieve high water quality standards across Europe, the Water Framework Directive (WFD) of the European Union, for example, establishes a framework for the protection of inland surface waters, transitional waters, coastal waters, and groundwater.

On the other hand, the legal and administrative frameworks required for effective water management are often absent from developing nations. Inadequate financial resources, technical skills, and fragmented policies and institutions make it difficult to execute water programmes effectively. Governance over water is further weakened by corruption and a lack of openness. Developing nations must prioritise institutional changes, capacity development, and community participation in order to improve water governance. Models of participatory governance, such as those seen in Latin American community-managed water systems, may enhance accountability and guarantee that local demands are taken into consideration when formulating policies.

Addressing water concerns requires the public's knowledge and participation. Effective strategies for involving the public and promoting sustainable water practices include media campaigns, neighbourhood workshops, and educational initiatives. Local water challenges have been successfully addressed by community-based initiatives, highlighting the significance of include local people in water management choices. Furthermore, corporate sustainability initiatives and collaborations with non-governmental organisations (NGOs) may support water-efficient techniques and contribute to clean water projects.

Conclusion, Limitations, Future Research Lines

The availability, quality, and management of drinking water in developed and poor nations differ greatly. Advanced infrastructure, strict laws, and technological expenditures have given developed countries dependable access to clean water. However, climate change-induced water scarcity, infrastructural degradation, and industrial pollution persist. Developing nations have poor infrastructure, financial resources, governance, and waterborne illness rates. Rural areas are more vulnerable to lack of clean water. Desalination, membrane filtration, and smart water management technologies may help. Due to their high prices and technological complexity, many underdeveloped nations cannot afford these advances. Industrialized nations have strong policy frameworks supported by large financial investments and good governance. Instead, poor nations should prioritize capacity training, financial investments, and effective governance to enhance water management. This research emphasizes the need for regional plans that use technology, reinforce regulatory frameworks, and engage communities to achieve water security and resilience. Global collaboration and financial commitment are needed to enable fair access to safe drinking water, improving public health, sustainable development, and economic prosperity. The intricate issues associated with the availability of drinking water need for a multidisciplinary strategy including economic investments, technical breakthroughs, efficient government, and community participation. Developed nations have to concentrate on preserving and modernising their current infrastructure, implementing sustainable water management techniques, and resolving water stress brought on by climate change. Conversely, developing nations must give basic water infrastructure development first priority, as well as monitoring water quality, strengthening of their governance systems, and securing foreign investment and financing. Collectively tackling these issues, the international community can ensure that everyone has fair access to safe drinking water, therefore advancing public health, sustainable development, and economic expansion. The results of this research emphasise the need of customised approaches for various areas, making use of technology developments, fortifying legislative frameworks, and encouraging community participation to attain resilience and water security.

This study used a limited sample size, which might not necessarily represent regional circumstances; to amplify validity, future research lines should utilize larger, more representative samples. Although the study compares industrialized and developing nations, its regional scope may restrict its applicability and usage, thereupon demanding the investigation of global drinking water concerns in more landscapes. The data is unchanging and may not precisely represent changes in water management and availability, underlining the necessity of expansive research to uncover trends and long-term impacts of water scarcity. While the research focuses on current technological conditions, it also maintains that developing countries might not easily get accustomed to these developments. The point underscores the need of conducting research to find practical and cost-efficient methods to bridge the technical gap, recognizing most of areas to profit from water management technologies. Policy-making is subject to changes depending on local political, economic, and social conditions. This

necessitates the use of flexible solutions that are correctly intended for local conditions, in order to guarantee the relevance and effectiveness of policy implementation. Furthermore, the financial analysis conducted in this study might not take into consideration the parameters in the economic aspects that have an impact on investments in water management. Consequently, it is vital to do thorough economic research to gain a full knowledge of the financial dynamics and make capable choices on resource allocation and investments in fluid economic situations.

It is crucial to continue researching cost-effective and easily expandable water filtration methods for developing countries. This includes exploring inexpensive desalination techniques, solar-powered purification systems, and breakthroughs in water recycling. Supplying this technology to less developed nations can greatly improve the quality and accessibility of water. An analysis of water-related policies and governance frameworks in various socio-economic contexts might assist in identifying optimal approaches that can be implemented in other areas. Effective water management necessitates robust policies and governance. It is essential to do research on the influence of climate change on water supplies and develop strategies for adapting to changes, especially in vulnerable areas such as communities living in worse welfare conditions. This will help us better understand the implications of climate change on water availability and find solutions to secure water security. Studying the involvement of local communities in water management and conservation is crucial for promoting sustainable water practices. By examining the roles of education, development of capacities, technology, along with aid from a non-profit and international organisations, we can single out solutions to intensify water management practices. It is crucial to recognize that community participation plays a vital role in the success of water management initiatives. Examining the economic consequences of water scarcity and pollution on various businesses, as well as conducting cost-benefit analysis of water management projects, would detect the financial ramifications of water scarcity issues, facilitating investment decisions and policy classification. Furthermore, it is vital to conduct long-term studies on waterborne illnesses, sanitation, and public health conditions in order to estimate the health impacts of enhanced water quality and access. The research will demonstrate the enduring advantages of investing in clean water.

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Appendix

Questionnarie:

The questionnaire for the master thesis intends to identify the approaches to ongoing challenges in the world related to drinkable water. Master's thesis study examines the drinkable water problem in the current world and estimates executive and management solutions for a wider audience. The study intends to gather information to give a clear view of the drinkable water problem in an extensive aspect and mitigate results for the master thesis at the Polytechnic Institute of Bragança and Khazar University in Azerbaijan to complete the double degree programme for Erasmus+ mobility. Answers to the questionnaire will be kept confidential and will only be used for research purposes. The following questionnaire will approximately take your 8-10 minutes to complete. Thank you for your collaboration and participation in the survey.

1. What is your gender?
    1. Male
    2. Female
    3. Other
2. What is your citizenship?
    1. EU citizen
    2. US citizen
    3. Citizen of developing country
    4. Other (please specify)
3. Where do you live?
    1. EU
    2. US
    3. In my own country (developing)
    4. Other (please specify)
4. What is your age group?
    1. Under 18
    2. 19-25
    3. 26-35
    4. 36-45
    5. 46-55
    6. 56 and above
5. What is your educational background?:_____

6. Would you consider that there is a different approach between public and private sector in terms of contributing to green economy and sustainability? Please rate from a scale of 1 (lowest) to 5 (highest).

1. To a Very Little Extent
2. To a Little Extent
3. Neutral
4. To a Large Extent
5. To a Very Large Extent

7. Which of the following best describes your current occupation? You can select one or more answers below:

1. University student
2. Private sector employee
3. Part-time worker university student
4. Public sector employee
5. Other (please specify)

8. How concerned are you about the drinkable water problem?

Please rate from a scale of 1 (lowest) to 5 (highest).

1. Very unconcerned
2. Unconcerned
3. Neutral
4. Concerned
5. Very concerned

9. What do you think are the main causes of the drinkable water problem? You can select one or more answers below:

1. Industrial pollution
2. Agricultural runoff
3. Urbanization
4. Deforestation
5. Infrastructure decay
6. Climate change
7. Other

10. Have you personally experienced any water-related issues in your area? Please rate from a scale of 1 (lowest) to 5 (highest).

1. Never
2. Rarely
3. Sometimes
4. Usually
5. Always

11. If you experienced the problem to a substantial degree, please describe the water-related issues

from your own point of view.

12. How do you think the private sector can contribute to solving the drinkable water problem?

13. How do you think the public sector can contribute to solving the drinkable water:_____

14. Based on your experience, on a scale of 1 to 5 (1-definitely not; 2-probably not; 3-unsure; 4-probably yes; 5-definitely yes), please rate likelihood of suggestions on increasing awareness for sustainability projects in the context of the drinkable water problem if applied successfully.

1. Likelihood to change behavioural pattern in the near future
2. Likelihood to revert the volume of awareness on environmental issues
3. Likelihood to reduce waste by private companies by raising issues in the communities
4. Likelihood to increase budget expenditures on sustainability projects by government
5. Likelihood to create self-initiatives by individuals to reduce waste in the neighborhoods

15. If you come across certain types of sustainable development organisations, please provide details about the successful initiatives you are aware of.

16. How important do you think it is to address the drinkable water problem? Please rate from a scale of 1 (lowest) to 5 (highest).
    1. Very unimportant
    2. Unimportant
    3. Neutral
    4. Important
    5. Very importan
17. How likely are you to support sustainable water management practices in your daily life? Please rate from a scale of 1 (lowest) to 5 (highest).
    1. Very unlikely
    2. Unlikely
    3. Neither likely nor unlikely
    4. Likely
    5. Very likely
18. What are the biggest obstacles to achieving sustainable water management in your opinion?

19. Would you be interested to pay more for products or services from companies that are committed to sustainable water management? Please rate from a scale of 1 (lowest) to 5 (highest).

1. Not at all interested
2. Less interested
3. Somewhat interested
4. Very interested
5. Extremely interested

20. What role do you think technology can play in addressing the drinkable water problem?

21. How do you think universities can contribute to raising awareness about the drinkable water problem?

22. What kind of information or resources do you think would be helpful in addressing the drinkable water problem?

23. How likely are you to recommend sustainable water management practices to others? Please rate from a scale of 1 (lowest) to 5 (highest).
    1. Very unlikely
    2. Unlikely
    3. Neither likely nor unlikely
    4. Likely
    5. Very likely
24. What do you think are the most effective ways to engage the public in addressing the drinkable water problem?

25. Do you have any additional comments or suggestions regarding the drinkable water problem?