European Journal of Sustainable Development Research
2023, 7(3), em0223
e-ISSN: 2542-4742
https://www.ejosdr.com

MODESTUM

Review Article

OPEN ACCESS

Addressing water resource management challenges in the context of climate change and human influence

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Citation: Adamopoulou, J. P., Frantzana, A. A., & Adamopoulos, I. P. (2023). Addressing water resource management challenges in the context of climate change and human influence. *European Journal of Sustainable Development Research,* 7(3), em0223. https://doi.org/10.29333/ejosdr/13297

ARTICLE INFO

Received: 08 Mar. 2023

Accepted: 14 May 2023

ABSTRACT

Background: Globally, natural water resources are not sufficient most of the times and do not meet the growing demand over the last five decades at least. Climate change is becoming more and more intense. As a result, multiple issues arise. This perspective study aims to identify and document current issues with managing water resources caused by climate change and the human aspect.

Results and purpose: Purpose of this study is to identify and record contemporary challenges regarding the management of water resources arising from both climate change and the human factor. Adverse public health from climate change, the process and management of water at a global level is at high risk and involves a big challenge.

Methodology: Methodology includes the review of various studies in the Greek and international academic community, which were drawn from the international databases Medline, Scopus, and PubMed. The exclusion criterion of the articles was the language other than English and Greek.

Conclusions: The narrative review studies the ways of water resources management, exposes the issues created due to lack of infrastructure, and concludes that a new water resources management framework needs to be updated and implemented. Also, greater investments must be made for the maximum utilization of existing water resources saving a lot of potable water.

Keywords: water resources, climate change, public health impact, environmental management challenges, human factor, global warming

INTRODUCTION

Water is equal to oxygen for the maintenance and creation of life. Without it, a person can survive for a couple of days at most for a week. Moreover, the safety and prompt availability of water is crucial for public health as water resource management can help eliminate poverty and improve quality of life (Ross, 2022). Climate change leads to the scarcity of potable water as it can easily be contaminated and lead to unforeseen circumstances (Ross, 2022).

The supply of water resources is divided into conventional and unconventional water resources, with the latter offering partial relief to water scarcity phenomena, where there are no renewable water resources (Duan & Duan, 2020; Mohsen & Al-Jayyousi, 1999). Most water transport projects are still in the very early stages although the food trade has become international with the inauguration of motorized transport–railway, ship, and airplane service (Qadir & Oster, 2004).

"Natural" water transfer to underprivileged areas could help dry areas achieve food security. The utilization of fresh water from surface water resources or under the ground and then, the transportation of water through large pipelines is a way of continuous flow movement like rivers and canals. Most water transport projects are still in initial stages. However, the food trade has become international since the operation of wagons, railways, ships and now planes (Duan & Duan, 2020).

Although food is imported in international food trade, the water used to produce the food imported into water-scarce countries with water shortages equates to large water savings for those countries (Zhuang, 2023).

Floods and droughts occur frequently, sometimes in the same area or in neighboring areas. Antithetically, most of the

available freshwater is concentrated in specific areas, while other regions have a shortage of water (Merrett et al., 2003). Water needs already exceed supplies in areas containing more than 40% people of the world's population since freshwater resources and population density are unevenly distributed around the world (Merrett et al., 2003; Rijsberman, 2006).

The situation in the Middle East and North Africa (MENA), which was depleted of renewable freshwater decades ago, has taken on alarming proportions, in the sense that the region is unable to meet its food needs using the available water resources (Bennett, 2000). The recently published maps highlight the ever-increasing number of countries that will have to deal with the water shortage. Predictions show that by 2025 about 60% of the world's population will have faced water shortages (Allan, 2002; Seckler et al., 2023).

The greater the pressure on freshwater resources in areas with water scarcity increases is, the greater the need to conserve and use conventional water resources more efficiently will be. This is due to future increases in agricultural production that will have to rely heavily on existing water resources (Vallee et al., 2003). Such conventional resources consist of water available from rainfall and avalanches, which is used on the spot or comes from rivers, streams, natural or artificial lakes and groundwater. The resources are renewable through the natural processes of the hydrological cycle.

RESULTS

The results and purpose of this study was to delve into the impact of climate change factors on water resources. Additionally, the identification and recording of contemporary challenges regarding the management of water resources arising from both climate change and the human factor. Due to the enormous number of impacts on human health and water resources that ultimately ended up in adverse public health from climate change, the process and management of water at a global level is at high risk and involves a big challenge. Given the ongoing pandemic scenario and other potentially harmful pathogenic microorganisms present in the environment, it should be assessed whether or not it threatens human health.

Methodology

A review of the published literature in Greek and English was carried out. The material of the narrative review includes published articles in Greek and international databases such as Medline, Scopus, and PubMed through the following indexing words: "water resources", "climate change", "public health impact", "environmental management challenges", "global warming", "policy and management", "human factor". This study included articles regarding water resources as well as climate change. The exclusion criterion of the articles was the language other than English and Greek.

Contemporary Challenges

It is extrapolated that over the last three decades, globally, people choose large cities to live in. As a result, the sustainable use of natural resources and economic prosperity are making great progress in metropolises and large urban centers (Kijne et al., 2004; Ligtvoet et al., 2014).

There is inevitably intense pressure on urban areas climate sensitivity, which includes the water resources cycle (AR5, 2013). Predicted urbanization will increase people in the next decades in developing countries about water-related challenges world's population (**Figure 1**) (Population Matters, 2023). Over the past decade, more than half of the world's population has chosen to live in cities, in flood-prone areas along the coast and major rivers (Program UNE, 2013). It is predicted that urbanization will increase with more than two billion people in the next three decades. This rapid urban development will take place mainly in developing countries and will bring about water-related challenges (Program UNE, 2013).

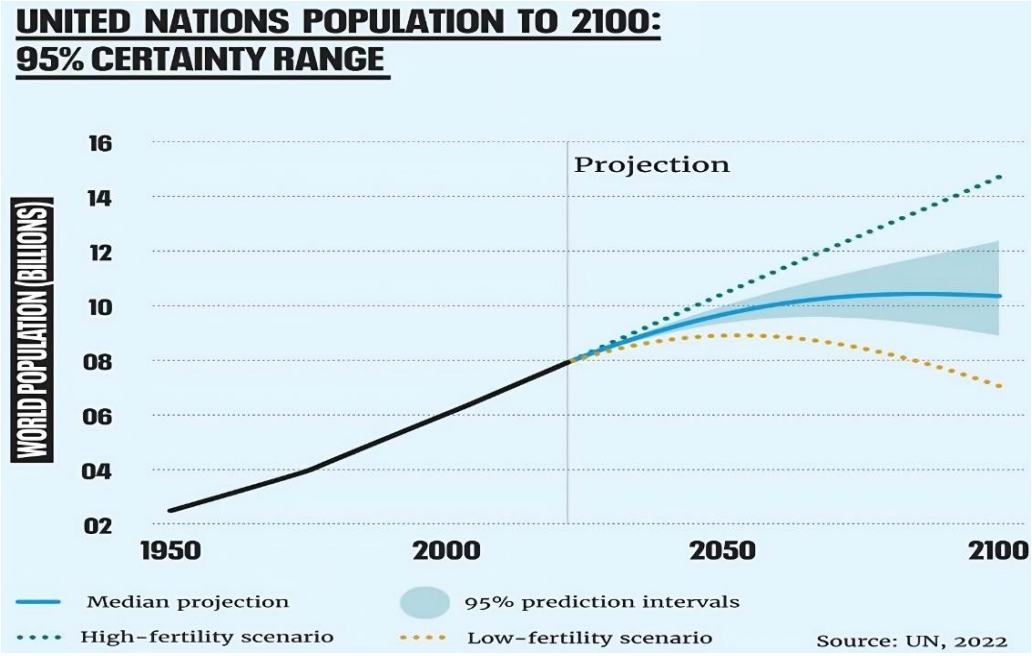

Figure 1. Predicted urbanization will increase people in next three decades in developing countries about water-related challenges world's population live in cities, in flood-prone areas along the coast & major rivers (Population Matters, 2023)

Over 600 million people, still, do not have access to safe potable water and 2.5 billion people lack improved sanitation: resulting in insufficient satisfaction of basic needs. Diseases related to unsafe water are caused by poor hygiene, and lead to about 1.7 million deaths per year (AR5, 2013; World Urbanization Prospects, 2023). The cost of climate change is high and will increase further, although it will vary by region. For instance, Europe is expected to be affected by climate change, however, the estimated damage of USD 240 billion by 2080 is significant (Ligtvoet et al., 2014; WHO, 2002). People tend to inhabit areas with coastline and river deltas while at the same time freshwater resources are limited and pollution is often observed, including the penetration of seawater. In addition, those regions are vulnerable to floods and climate change (Population Matters, 2023; Program UNE, 2013).

Rapid urbanization can lead to large-scale surface pollution and depletion of freshwater resources after floods. Often urban territory is largely "sealed" by buildings and paved infrastructure. Therefore, rainwater cannot penetrate, resulting in a decrease in groundwater recharge and an increased risk of flooding urban sewers (Kijne et al., 2004). Most cities are vulnerable to flooding because they are close to rivers and seas. Sea level rise and the rise in extreme river discharges make up the projected 15% of the world's population at risk of flooding. It also concerns urban areas, which include almost all the major cities of the world (Ciscar et al., 2014).

About 30% of the population of big cities live in arid areas (Shuster et al., 2007). By 2030, the world will have experienced about a 40% shortage of fresh water (Sekovski et al., 2012). Global water demand will increase by 55% between 2000 and 2050 and over 40% of the world's population is projected to live in river basins (Sekovski et al., 2012). In addition, water withdrawals are estimated to increase by 50% by 2025 in developing countries and by 18% in developed countries (Shuster et al., 2007; WRG, 2009). Climate change will cause increased drought, limit freshwater availability and groundwater recharge, and enhance the spread of water-borne diseases (Ligtvoet et al., 2014).

Water Resources Management

Water services are of financial interest. As far as the European Union is concerned, they are mainly regulated at national level and water services differ amongst countries. Water management is the result of historical and cultural factors. As a result, four management models for Europe can be distinguished:

1. **Direct public management:** In the direct public management system, the responsible body provides integrated services and manages them. This system dominated Europe in the past (UNESCO, 2006).
2. **Delegated public management:** In the system of delegated public management, the competent body appoints a manager to perform the necessary tasks. Management bodies are usually in the public sector, but they can also be secondary private participations (UNESCO, 2006).
3. **Delegated private management:** In the system of delegated private management, a private company is appointed to manage tasks by the competent public body. The appointment is made through a lease or a concession agreement. Municipalities may also subcontract their tasks to private law companies (UNESCO, 2006).
4. **Direct private management:** In the system of direct private management, private entities have full responsibility and ownership of utilities. Public bodies are limited to control and regulation (European Environment Agency, 2023a; UNESCO, 2006).

Climate Change

Pollutants

A prerequisite for life and sustainable development is access to clean water. Particularly, pollutant emissions from large cities, reduce biodiversity and burden human health. Untreated sewer discharges, combined sewer overflows, solid waste pollution and stormwater runoff are the biggest causes of urban water pollution (European Environment Agency, 2023b). Surface and overland water runoff from sealed surfaces such as asphalt and cement prevents penetration and creates runoff peaks. This water is contaminated e.g., with oil, grease and toxins from motor vehicles, road salts and heavy metals (Finotti et al., 2014; Shuster et al., 2007).

The pollutants mentioned above cannot be purified and filtered by the soil processes and flora of each region. Secondary wastewater treatment is a prerequisite for adequate water quality (Kijne et al., 2004). Therefore, improved access to the drain must be combined with wastewater treatment to avoid an increase in the effect of sewage sewers (Batten & Rottle, 2012). It is inevitable that nutrient emissions in Asia and Africa will double or triple over the next four decades. This will cause eutrophication, biodiversity loss and threaten potable water, fisheries, aquaculture, and tourism (Kijne et al., 2004). Huge amounts of solid waste are produced while they release hazardous substances and nutrients. Especially, plastics easily enter rivers, and eventually, the oceans. Weather processes reduce these plastics to small particles that are not biologically degradable, but they are toxic. The problem of plastics has led to their accumulation in parts of the oceans. For example, plastics form a "soup" in the Pacific Ocean that covers twice the area of the United States and affects many marine animals through ingestion (Grimm et al., 2008).

Global warming

Heat waves pose multiple health risks, particularly as regards the elderly. In recent decades, you have noticed the "urban heat island" phenomenon, where cities are exposed to extreme heat, up to 10°C higher temperature than non-urban areas (Zarfl et al., 2011). This phenomenon will enhance the severity of heat waves that occur more frequently and intensely due to climate change (EU, 2023).

Infrastructure

Annual expenditure on water infrastructure for developed countries currently amounts to around 1% of GDP. For developing countries, this is about 3.5% (Baccini et al., 2011). The widespread need for accelerated infrastructure investments is exacerbated by increased adaptation costs

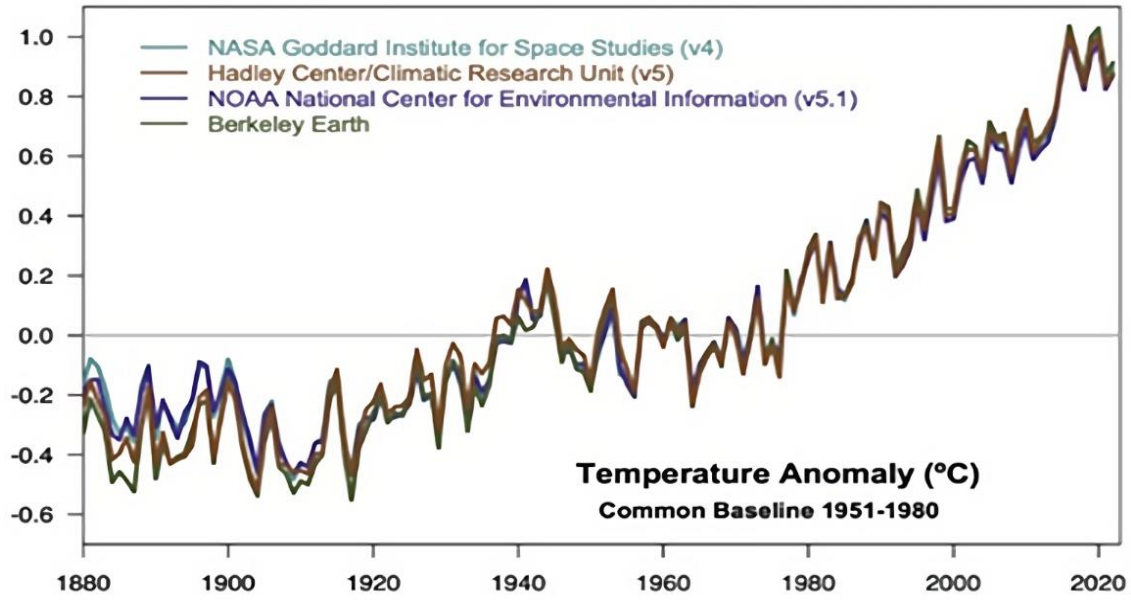

Figure 2. Temperature data showing rapid warming in the past few decades, the latest data going up to 2022 (according to NASA, 2016 and 2020 are tied for the warmest year since 1880, continuing a long-term trend of rising global temperatures) (NASA, 2023)

related to climate change to combat weather abnormal patterns, extreme rainfall, and water scarcity (Cashman & Ashley, 2008; Gessner et al., 2014).

It is crucial to reevaluate the interaction between people and the environment and to promote more sustainable behavioral choices. Science data demonstrates that the emergence of new viruses (Adamopoulos et al., 2023b, 2023c). Pathogens having a high potential for epidemics and pandemics are frequently the outcome of intricate interactions between people, animals, and the environment (Adamopoulos et al., 2023b).

In recent decades, you have noticed the "urban heat island" phenomenon, where cities are exposed to extreme heat, up to 10 °C higher temperature than non-urban areas (AR5, 2013). This phenomenon will enhance the severity of heat waves that occur more frequently and intensely due to climate change (Population Matters, 2023). Temperature data showing rapid warming in the past few decades, the latest data going up to 2022. According to NASA, 2016 and 2020 are tied for the warmest year since 1880 given the temperature anomaly in **Figure 2** (NASA, 2023).

Environmental & Public Health Issues & Contemporary Challenges

Better assessment of the risks and impacts of exposure would allow for improvements in wastewater management and in the design of appropriate protective measures. Initial evaluations of epidemiology tools are difficult to control, methodological complications and uncertainties regarding the assessment of both exposure and health outcomes. It is necessary pollution be monitored for recording and assessment tools provide recognition of the key role and management of the administrative control of environmental wastewater. Risk context of surveillance allows all the hazards to be recognized and investigated.

Guidelines and holistic policy of public health services that determine contamination are important factors in providing control measures, improving efficiency and preventive measures. Individuals and public health workers are exposed to various health risks regarding wastewater.

1. Primary risks are direct, acute health threats such as heat waves and floods.
2. Secondary risks are indirect, yet readily observable pathways between environmental perturbations and human health.
    a. Impacts on human health and public health system are influenced by climate and other environmental factors. Many studies address human and public health system within a systems-level framework that accounts for both direct and indirect effects.
    b. Metrics and analysis of database of environmental and socioeconomic variables, create model of direct and indirect effects on worldwide public health.
    c. Indicators, used age mortality rate and an index of biological integrity in streams and rivers, air pollution and wastewaters climate set boundary conditions for all other variables hydrology and land cover have predictable but distinct effects on public health, link between the environment and the socioeconomic variables that directly influence human health. Humans health influence on climate change associations and correlations factors impacts, vulnerability and public health reflect on research. Rivers and their watersheds provide a uniquely well-integrated context for research on social ecological systems. Most human populations depend on revering ecosystem services, while the watershed is a natural geospatial unit for modeling environmental exposure and predicting epidemiological outcomes (Corley et al., 2018).

Figure 3 shows climate change and human health with impacts, vulnerability, and public health (Haines et al., 2006).

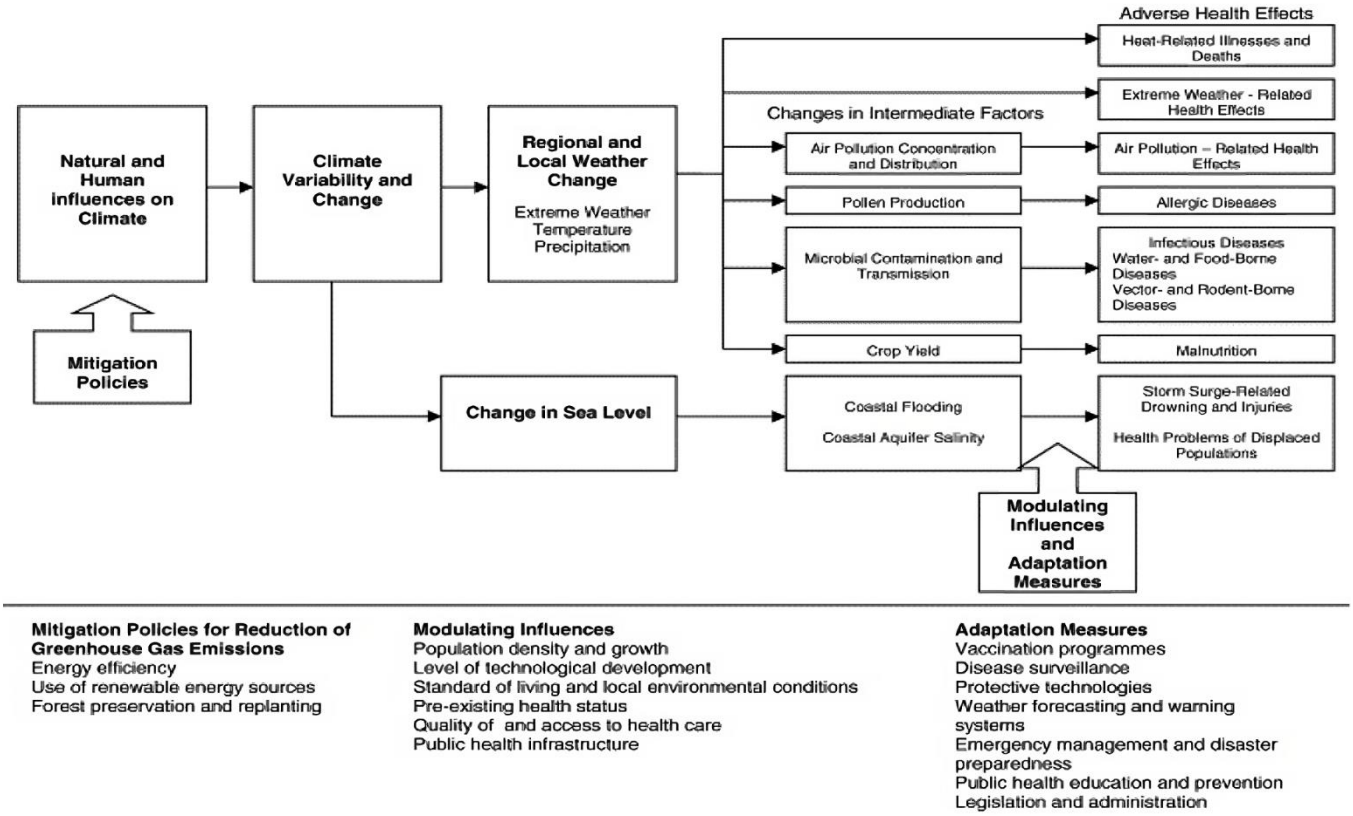

Figure 3. Climate change & human health: Impacts, vulnerability, & public health (Haines et al., 2006)

DISCUSSION

It is a fact that there is not enough data available from exposure to urban wastewater and the effects on citizens' health. The volume of wastewater produced worldwide is very high, even from infrastructure wastewater. The world's population is at risk from environmental exposure or public health exposure to limited waste management in the field of public health (Zhuang, 2016).

Rapid urbanization can lead to large-scale surface pollution and depletion of freshwater resources after floods. Often urban territory is largely "sealed" by buildings and paved infrastructure. Therefore, rainwater cannot penetrate, resulting in a decrease in groundwater recharge and an increased risk of flooding urban sewers (Kijne et al., 2004).

The organizational elements and sociopsychological hazards in the workplace of public health services in Greece and how they affect employees have been the subject of various studies and publications of articles and papers in international conferences over the past two years (Adamopoulos, 2022a, 2022b; Adamopoulos & Syrou, 2023; Adamopoulos et al., 2022b, 2022c, 2022d, 2023a, 2023b). Public health audit services are managed by authorities (Adamopoulos, 2022c, Adamopoulos & Syrou, 2022a, 2022b; Adamopoulos et al., 2022a, 2022b, 2022e). Another factor influencing performance and the provision of high-quality services to society is job discontent among employees and the need for training and excellent education among public health professionals. The pressure from politicians and administrators combined with urban and semi-urban environments have a negative impact on the operation of public health services, which was especially evident during the COVID-19 pandemic (Adamopoulos, 2022d; Adamopoulos & Syrou, 2023). Burnout is observed in employees and consequently affected and increased by political interventions. In order to ensure efficient operation, openness, and government control over the administrative apparatus in Greece, leadership in the service sector is crucial (Adamopoulos, 2023).

CONCLUSIONS

Several countries worldwide are facing significant water resource shortages. Conventional water resources need to be managed through new technologies to meet all needs. It is vital the relationship between humanity and environment be reconsidered and more sustainable behavioural choices to protect global public health. There is an urgent need to create a better institutional, regulatory, and organizational framework for the transportation and reuse of water. Furthermore, the allocation of more funds to wastewater treatment is vital.

It is essential immediate creation of large investments be made in order to enable urban and coastal areas to adapt to the new realities and mitigate the urban climate. Infrastructure and urban planning are the key to sustainable integrated water resource management, but it requires great investments and long-term planning.

Author contributions: All co-authors have involved in all stages of this study while preparing the final version. They all agree with the results and conclusions.

Funding: No funding source is reported for this study.

Acknowledgements: The authors would like to thank European University of Cyprus and especially School of Science, Department of Health Science, School of Medicine, and the CERIDES Research Center, also the University of West Attica and School of Public Health.

Declaration of interest: No conflict of interest is declared by the authors.

Ethical statement: The authors stated that ethical approval of the research was carried out in accordance with the rules and current Bioethics Legislation, all the conditions and specifications of the National and European Union Legislation for the protection of personal data as well as in accordance with the instructions of the quality assurance and the study was carried out according to the Declaration of Helsinki.

Data sharing statement: Data supporting the findings and conclusions are available upon request from corresponding author.

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