



Impact of water insecurity amidst endemic and pandemic in Pakistan: Two tales unsolved

1. Water insecurity in a global context

Water insecurity is defined in broader terms as a “deficiency in the availability and access to adequate safe and clean water to the common man that is not only important for his physical and mental wellbeing but also to perform daily, healthy living activities and household chores.” [1] Water insecurity has become a global concern, significantly affecting low- and middle-income countries.

The unavailability of safe and clean water has not only a significant impact on drinking but also on basic hygiene practices at homes, offices, schools, etc. The adverse effects caused by water insecurity are innumerable, affecting every living being in a community (including plants, animals, etc.), ranging from minor ailments to large-scale social and political tensions, stunted growth in children, and exacerbating epidemics [2].

Recently a study conducted showed that water scarcity tends to increase the severity of depression symptoms in many underdeveloped countries [3]. The economic burden on the countries indirectly depends on water availability, as water insecurity leads to food insecurity, poor maternal health, malnutrition, and stunted growth in children, which adversely affects the workforce of a country [4].

Also, the water shortage for hydroelectric power generation and agricultural production ultimately leads to the country's economic crisis. Water scarcity leads to deadly diarrheal diseases, which become a challenge for a country's health system. Water scarcity and overuse of agricultural pesticides threaten food safety which has become a significant trouble health care system today in many countries [5]. Food insecurity leads to compromised nutrition, poor physical and mental health such as anxiety problems, depression, and chronic diseases of adulthood such as diabetes, hypertension, cancer, etc. [6] If the demand for adequate clean and safe water continues to rise at the current pace and no effective measures are undertaken, two-thirds of the world population will be facing solemn water scarcity by 2025 [7].

In-accessibility to safe and clean water depends on numerous factors such as lack of infrastructure [8], drastic climate changes [9], population explosion [10], and pollution [11], adversely affecting people in both developed and third world countries. Water scarcity is one of the prominent examples creating havoc not only for humankind but also for plant and animal life. The problem of water scarcity has been elevated during the COVID19 pandemic as preventive measures for this pandemic regularly include handwashing, physical distancing, and household cleaning, so the hurdle faced by ordinary men today during the pandemic is water scarcity [2].

In many middle- and low-income countries, when water will be accessible only in limited places, overcrowding will further aggravate the deadly disease. Social distancing will not create a vital obstacle to warding off this virus. This research documents how water scarcity

limits the measures for warding off this pandemic. This short communication would also help the public authorities for making adequate policies for securing insufficient water and would create public awareness of the importance of the availability of safe and clean water for humanity.

2. Water insecurity in Pakistan

With the current 30-day water storage capacity, some 207 million people will face ‘absolute scarcity of water, with less than 500 cubic meters available per person by 2025 [12]. Despite having the great Indus River and some of the world's largest glaciers, water shortage is widespread in Pakistan [13]. Even having many reserves, and almost 5000 glaciers, Pakistan cannot harness its use systematically [14].

Nearly 97% of water is used for agriculture, and the remaining 3% is used for domestic, industrial, and other purposes [15]. The insecurity keeps on fluctuating due to mismanagement political and meteorological reasons. However, it has become a consistent issue of concern since COVID-19 hit Pakistan. Preventive measures for COVID-19, as mentioned earlier, have increased the water demand. Due to the imbalance between demand and supply of water during the COVID-19 era, access to safe water has reduced significantly. It is estimated that by 2025 Pakistan will face acute water scarcity [16].

Water security is an urgent point of concern in Pakistan [17]. Almost all regions of the country are affected by it. In Thar, Pakistan, lack of water has always been an issue. Nearly 1500 children in Thar die every year due to drought, malnutrition, and insufficiency of wash facilities such as water supply system and sanitation system which leads to diarrheal deaths of inhabitants of Thar and COVID has only exacerbated the situation [18]. In Lahore, groundwater levels are going down by 1 m per year, and related authorities aren't doing enough to deal with it [19].

As per IMF, Pakistan's per capita annual water availability has reduced from 1500 cubic meters in 2009 to 1017 cubic meters in 2021 [20]. It is estimated that by 2025 it will fall to 274 million acre-feet (MAF) while the resources remain the same at 191 MAF, a demand-supply gap of approximately 83 MAF [21].

According to the experts, 7-million-acre feet of water is lost to the sea every year due to the incompetence of government, and lack of strategy and infrastructure. In the government's case, there is never a long-term policy to deal with the crisis. Also, Pakistan has dams that reserve water only for 30 days while in other South Asian countries it's more, such as in India it's 220 days. All these factors are leading the country to a famine-like situation [22].

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3. Factors causing water insecurity in Pakistan

The decline in water availability in Pakistan primarily stems from three factors; these include mismanagement on behalf of the government, lack of awareness, and politics between provinces [20]. Mismanagement is multifold, extending from lack of advancements to excessive water in Pakistan. Farmers do not use hybrid seeds for cultivation, use mangroves and other traditional farming styles with low efficacy that deplete water in Pakistan [23].

Furthermore, climate change also plays a role via changes in rain patterns, increasing temperatures, and flooding. This results in water scarcity via lowering the groundwater level and rising evaporation in Pakistan. The groundwater level is also depleting at an alarming rate. Besides climate change, excessive tube wells and the allowance to pump out any amount of water further weakens the groundwater level [24].

Lack of awareness, among farmers and the general public, regarding the need to conserve water and the use of high-efficacy irrigation systems is another challenge to be dealt with in Pakistan [25]. Our population is also exploding at an alarming rate. We are among the countries having the highest growth rate [26]. Combined with increasing population, urbanization, unregulated industrialization, and lack of aquifers contribute to the looming water crisis in Pakistan [27].

4. Endemic diseases in Pakistan in relation to the effect of water insecurity

Integrated water resource management lies at the heart of SDG 6 (Sustainable Development Goals). The international community resolves to ensure universal availability and sustainable management of water and sanitation as SDG6 by 2030 [28].

Looming water scarcity poses many health-related implications since rising temperatures have led to global precipitation changes developing drought-like conditions. "One of the worst droughts in Pakistan's history has triggered "alarmingly high" levels of malnutrition and disease in the hardest-hit areas where people have been forced to drink salty or contaminated water," the Red Cross said [29].

In Tharparkar in 2016, drought-related waterborne and viral diseases have claimed the lives of 190 children along with more than 22,000 hospitalizations [30]. Exponential population growth in Pakistan has changed the calculus of water demand and reduced the per capita water availability. Metropolitan cities like Karachi lack sound water management and face a Cape Town-like "day zero situation." [31].

"Mere access is not enough. If the water isn't clean, isn't safe to drink, or is far away, and if toilet access is unsafe or limited, then we're not delivering for the world's children," says Kelly Ann Naylor, Associate Director of Water, Sanitation and Hygiene, UNICEF [32].

According to the 2017 WHO and UNICEF Joint Monitoring Programme (JMP) report, more than 40% of the world's population lacks basic handwashing facilities [33]. A statement by the Pakistan council of research in water resources showed that most samples from various areas of Sindh were found unsafe, and major contaminants were bacteria, turbidity, and TDS (total dissolved solids) [34].

Gastrointestinal and respiratory illnesses become more rampant when water is not handwashing. Around 160 million children worldwide suffer from stunting and malnutrition, attributed to a water shortage [35].

According to an International Union for Conservation of Nature (IUCN) report, infant deaths from water-related diarrhea account for 60% of all deaths in Pakistan, the highest in Asia [34]. Around 53000 children die from diarrhea caused by contaminated water every year in Pakistan [36]. Because the water table goes down day by day, pumps draw more profound where arsenic content is naturally higher. In Pakistan, approximately 60 million people are at risk of being exposed to high levels of arsenic in drinking water, the most significant mass

poisoning in history [37].

As the saying goes, "handwashing is the 'do it yourself vaccine'" UNICEF started promoting a three-star approach for WASH (water, sanitation, and hygiene) services in schools [38]. In the context of the current pandemic, HWWS (handwashing with water and soap) being an effective means to control the transmission of infection, equitable access to WASH services was recommended by WHO to be an important element of prevention strategies.

Availability of safe and clean water in adequate amounts also became the need of the hour at various points of care, e.g., wards, treatment rooms, delivery rooms, and postnatal care rooms for cleaning and disinfection purposes. Both of these factors precipitated water shortage [39].

"If countries fail to step up efforts on sanitation, safe water, and hygiene, we will continue to live with diseases that should have been long ago consigned to the history books: diseases like diarrhea, cholera, typhoid, hepatitis A and neglected tropical diseases including trachoma, intestinal worms, and schistosomiasis." [32].

5. Water insecurity amidst COVID-19 pandemic in Pakistan

Water insecurity is already a significant social, environmental, and economic development challenge for Pakistan. In recent years, climate-induced disasters (floods and droughts) have spotlighted the necessity to introduce climate-resilient solutions for improved water governance at all levels [40]. Pakistan had a relatively abundant supply of water. In 2000, Pakistan had become water-stressed, and by 2035, Pakistan is predicted to have become water scant [40].

In addition, COVID-19 has underscored the importance of reinforcing the resilience of potable water supply systems. Thus, Pakistan's increasing water scarcity and vulnerability to climate change highlight the urgent need to manage climate-related risks and improve water use at the national and local levels.

Pakistan ranks third in the world among countries facing acute water shortages. Reports by the United Nations Development Programme (UNDP) and the Pakistan Council of Research in Water Resources (PCRWR) also warn the authorities that the South Asian country will reach absolute water scarcity by 2025. Pakistan is approaching the scarcity threshold for water. Even more disturbing is that groundwater supplies — the last resort of water supply — are being rapidly depleted [40].

COVID-19 highlights the inequalities, hardships, and global health risks that result from the collective failure to uphold the human right to water and sanitation. In many communities, a lack of water supply and sanitation deprive people of their most basic protections against the spread of the virus. The water crisis in Pakistan is relentless. Residents have been dealing with water shortages for a while now [41].

Improving water, sanitation, and hygiene has the potential to prevent at least 9.1% of the global disease burden and 6.3% of all deaths, according to the World Health Organization (WHO) report Safer Water, Better Health, released before the pandemic. Nevertheless, many go without safe sanitation services and lack basic handwashing facilities [42].

Moreover, diarrheal diseases caused by waterborne pathogens and poor hygiene inhibit nutrient absorption, so even those with access to adequate nutrition may face malnutrition. This means that where handwashing is limited and waterborne illness is already familiar, not only will COVID-19 spread more quickly but its lethality could also be amplified [42].

In some areas, lockdowns have impacted agricultural cycles, intervening inputs, depressing demand, and keeping workers away from fields and factories. When farming activities resume normal, demand for irrigation water may rise quickly if dry season cropping expands to counter food supply deficits. Thus, a critical priority will be preparing for potentially significant unplanned irrigation withdrawals, ensuring

they do not undermine basic domestic water needs or overdraw aquifers, lakes, and rivers [43].

The risk of natural disasters—including drought, extreme weather, and flooding—occurring during the pandemic is another significant problem that threatens water security and long-term recovery. People displaced by disasters are typically relocated to densely populated camps or shelters where authorities may struggle to meet essential water, sanitation, and hygiene needs—and now, where the novel coronavirus could spread rapidly. The food production and trading systems are more buoyant to water challenges.

To bolster domestic food supplies from COVID-19 disruptions, few countries have restricted exports and changed agricultural production patterns. In addition to potential impacts on global prices, poverty, and hunger, such moves affect water availability and undermine the resilience of food systems in Pakistan [43]. Through the analysis of Pakistan's domestic water systems, out of more than 200 million people, 70% do not have access to safe drinking water, and 80% do not have access to both safe drinking water and sanitation combined [43].

Currently, amidst a ticking timebomb where more than 200 million people will be water starved if we do not act now. This is increasingly evident from growing water scarcity, resource depletion, and contamination in many parts of the country due to multiple factors, significantly increased rate of COVID-19 [43].

COVID-19 has, like nothing that has gone before, revealed the systems wiring of the modern, globalized world and how destructive disturbances to those systems can be. Water connects health, food systems, climate change, nature, energy, and finance. Thus, water has critical implications for the effectiveness of COVID-19 response efforts and for promoting growth and building resilience in a post-pandemic world.

6. Challenges at hand

Water is the basic necessity for the survival of humankind. As water insecurity is rising, it is causing detrimental effects on health standards and is making survival more challenging. Especially in COVID 19, where hand washing, cleanliness, and good hygiene are a must to prevent infectious diseases, measures against the spread of COVID are compromised in water-insecure areas. Rural areas and informal settlements in urban areas are deprived of clean water, good sanitation, and hygiene services.

Also, the lack of safe and clean water due to pollution, open defecation, and saltwater intrusion, has made it more challenging to control COVID-19 in rural and urban areas [44]. Household water insecurity is leading to malnutrition. Maternal-child health is also being affected, particularly in the Rajanpur district, southern- Punjab. In the same region, there is the highest stunting and diarrheal infections prevalence [45].

In addition to households, schools are also deprived of hygienic conditions. Only 57% of students have clean drinking water, and 28% do not have good sanitation facilities. The WASH sector that deals with the provision of clean water formulated its policy for controlling coronavirus in 2020.

This policy and plan couldn't work because of some challenges such as depletion of groundwater in Lahore and Quetta, insufficient water data, unsustainable levels of water withdrawal, widespread pollution, and low agricultural water productivity. The rise in population makes it difficult to estimate the demand and supply accordingly. It is expected that by 2047 the population will exceed 300 million.

At the government level, lack of resources, finances, structure, and management; inadequate legislative framework, and national strategic plans have a significant role in the failure of WASH policy [46].

Water supply varies throughout the country due to mismanagement and lack of reforms in structure and policies. Unequal distribution has compromised the handwashing and cleanliness campaigns to prevent the spread of coronavirus. In Punjab, 58% of households have water supply, KPK 22%, Sindh 7%, and Baluchistan 3% [47].

Also, superadded factors worsen the situation. Climate changes made Pakistan vulnerable to drought, heat strokes, and other medical illnesses. In 2018, 65 people in Karachi died due to heatstroke because of the unavailability of water [48].

Pakistan has the world's 4th highest rate of water use; this makes it is an economy more water-intensive than other regional countries. As 97% of the water is used for agriculture and irrigation, water scarcity can be a significant crisis. Pakistan majorly exports crops, an essential contributing factor in its economy. Insecurity of water will affect it drastically and can threaten the economic security of the country, particularly when national financial revenue is already compromised due to lock-down [49].

7. Efforts

Multiple projects/efforts have been conducted at the private as well as government levels. Drip and sprinkler system irrigation technique has shown to be highly effective in conserving water. However, it is still a challenge to make its use widespread across all agricultural areas of Punjab [49]. There have been multiple campaigns at private levels which highlighted the need to save water among the general population.

Still, a proper initiative on the part of the government is required [50]. To face the problem of lack of storage, the construction of Diamer Bhasha Dam was started in 2020 [51] after a crowdfunding drive was initiated by one of the top judges in Pakistan in 2018. However, it faces two significant problems: the lack of funds and the opposition of local communities [52]. Estimated to be completed by 2028 [51], this dam can support both the water crisis and energy crisis in Pakistan.

Due to climate change, the duration of the monsoon has become shorter, which means heavier rainfalls causing flooding. Lahore has developed a rainwater harvesting system near Lawrence Road, which conserves 1.4 million gallons of water.

Expanding this efficacious system across the country remains an issue [53]. There are plants that 'desalinate' (i.e., remove salts) from seawater, making it useable. Many of these plants were installed at Gwadar port, Balochistan, under the CPEC project by a Chinese company. This has provided more than 250 thousand gallons of drinking water to thousands of households in Gwadar [54].

8. Recommendations

Following are the recommendations for preventing and alleviating hazards of global water insecurity.

1. Creating awareness among people about the scarcity of accessible, safe, and clean water by several education programs and appealing advertisements to the layman highlighting the importance of clean water for drinking and proper nutrition.
2. New scales for measurement of water and food security should be evolved and requires attention and investment by authorities for better preservation at the level of population [55].
3. Recycling of wastewater can lead to the prevention of water insecurity to some extent; however, many studies are being done to establish an association of recycled water to waterborne diseases and the role of contaminants in recycled water to the health of individuals [56].
4. By increasing water efficiency for the agriculture sector, global water insecurity can be reduced. Wastewater by the agriculture sector can be reduced by better strategies on national water, which increase the capacity of water efficiency, but it is a long-term process. Consumption of such crops that require a large amount of water should be reduced. This change of consumption strategy requires effective awareness among people about water scarcity. Similarly, water needed for industries (such as clotting and automobile industries, etc.) should be efficiently used.

5. Investments inadequate supply of clean water infrastructure should be made at the national level. Along with long-term solutions to this global hazard, water conservation strategies such as the building of dams, awareness programs on careful usage of clean water, and reduction in large-scale wasting of water should be policy makers' targets [57].
6. Measures for water access, utilization, and reliability (i.e., whether the water supply is consistent or not) should be made effective and efficient [58].

9. Conclusion

Water insecurity is a global challenge despite focusing on many international policies. The number of water-scarce countries is expected to double in the coming years. Water stress is perceived to be physical scarcity owing to ecological conditions. Still, it is, in fact, economical due to either lack of infrastructure or poor management if the infrastructure is there in place. Combined with increasing population, urbanization, unregulated industrialization, and lack of aquifers also contribute to the looming water crisis in Pakistan. In COVID-19, where hand washing, cleanliness, and good hygiene are a must to prevent infectious diseases, measures against the spread of COVID are compromised in water-insecure areas. Water quality interventions to reduce the diarrhea toll and other globally endorsed measures are necessary to curb water insecurity. If we fail to act now, the cost of inaction on water insecurity will prove to be greater than the cost of action. We would be facing more "DAY ZEROES" "Meeting humanity's increasing demand for freshwater and protecting ecosystems at the same time, thus maintaining blue water footprints within maximum sustainable levels per catchment, will be one of the most difficult and important challenges of this century." [59].

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Sibgha Ali: Water Insecurity (global context) and Recommendations.
 Jaudat Zahra: Water Insecurity (the current state in Pakistan, statistics, reports) and Challenges.
 Mohsan Ali: Factors causing water insecurity in Pakistan Efforts.
 Sana Iqbal: Endemic diseases in Pakistan and Conclusion.
 Sidrah: Water Insecurity amidst COVID-19 in Pakistan and References (compilation and editing).
 Maliha Tahir: participated in write up.
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None.

References

- [1] P. Webb, M. Iskandarani, Water Insecurity and the Poor: Issues and Research Needs, 2022, <https://doi.org/10.22004/ag.econ.279785>.
- [2] J. Stoler, J. Miller, E. Adams, F. Ahmed, M. Alexander, G. Asiki, et al., The household water insecurity experiences (HWISE) scale: comparison scores from 27 sites in 22 countries. <https://doi.org/10.1016/j.ijheh.2021.11371>, 2022.
- [3] Y. Lu, S. Song, R. Wang, Z. Liu, J. Meng, A.J. Sweetman, et al., Impacts of soil and water pollution on food safety and health risks in China, *Environ. Int.* 77 (2015) 5–15.
- [4] F. Ahmed, M. Shahid, Y. Cao, M. Qureshi, S. Zia, S. Fatima, et al., A qualitative exploration in causes of water insecurity experiences, and gender and nutritional consequences in South-Punjab, Pakistan, *Int. J. Environ. Res. Publ. Health* 18 (23) (2021), 12534. <https://pubmed.ncbi.nlm.nih.gov/34886260/>.
- [5] R. Mushavi, B. Burns, B. Kakuhihire, M. Owembabazi, D. Vořechovská, A. McDonough, et al., "When you have no water, it means you have no peace": a mixed-methods, whole-population study of water insecurity and depression in rural Uganda. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC69363>, 2022.
- [6] M. Maynard, L. Andrade, S. Packull-McCormick, C. Perlman, C. Leos-Toro, S. Kirkpatrick, Food insecurity and mental health among females in high-income countries, *Int. J. Environ. Res. Publ. Health* 15 (7) (2018) 1424. <https://pubmed.ncbi.nlm.nih.gov/29986420/>.
- [7] N. Bulled, The effects of water insecurity and emotional distress on civic action for improved water infrastructure in rural South Africa, *Med. Anthropol. Q.* 31 (1) (2017) 133–135.
- [8] M. Feed, S. Ranking, Q. A. M. Africa, S. Africa, Lack of water and infrastructure management could lead to water scarcity by 2025 in South Africa [Internet], *Smart Water Mag.* (2022) [cited 20 February 2022], <https://smartwatermagazine.com/bl ogs/moegamad-zaid-railoun/lack-water-and-infrastructure-management-could-lead-water-scarcity-2025>.
- [9] M. Hussain, S. Mumtaz, Climate change and managing water crisis: Pakistan's perspective, *Rev. Environ. Health* 29 (1–2) (2014).
- [10] A. Boretti, L. Rosa, Reassessing the projections of the world water development report, *npj. Clean Water.* 2 (1) (2019).
- [11] Water scarcity across the globe | waterlogic [Internet]. Waterlogic.com., [cited 20 February 2022]. Available from: <https://www.waterlogic.com/en-us/resource s-blog/water-scarcity-across-the-globe/>, , 2022.
- [12] Z. Durrani, M. Marri, Water – the lifeblood of tomorrow [Internet], UNDP (2020) [cited 20 February 2020]. Available from: <https://www.pk.undp.org/content/pakistan/en/home/blog/2019/water--the-lifeblood-of-tomorrow/>.
- [13] M. Zulfikar, Water crisis in Pakistan: facts and solutions [Internet], *The Nation* (2020) [cited 23 February 2020]. Available from: <https://nation.com.pk/07-Aug-2020/water-crisis-in-pakistan-facts-and-solutions>.
- [14] S. Baloch, Water crisis: why is Pakistan running dry? [Internet], *DW* (2018) [cited 7 June 2018]. Available from: <https://www.dw.com/en/water-crisis-why-is-pakistan-running-dry/a-44110280>.
- [15] A. Salman, Pakistan's looming water crisis [Internet]. East Asia Forum, [cited 13 November 2021]. Available from: <https://www.eastasiaforum.org/2021/11/13/pakistans-looming-water-crisis/>, 2021.
- [16] H. Yusuf, The biggest problem [Internet], *DAWN* (2020) [cited 30 November 2020]. Available from: <https://www.dawn.com/news/1593187>.
- [17] T. World Bank, Pakistan's scarce water can bring more value to people and economy [Internet]. The World Bank, [cited 4 February 2019]. Available from: <https://www.worldbank.org/en/news/press-release/2019/02/04/pakistans-scarce-water-can-bringmore-value-to-people-and-economy>, 2019.
- [18] R. Tahir, A drought-stricken and marginalised Tharparkar: the right to water and COVID-19 in Pakistan [Internet], *Oxford Human Rights Hub* (2020) [cited 24 July 2020]. Available from: <https://ohrh.law.ox.ac.uk/a-drought-stricken-and-marginalised-tharparkar-the-right-to-water-and-covid-19-in-pakistan/>.
- [19] A. Raza, Lahore water level stops declining first time in history [Internet]. *The News*, [cited 21 June 2021]. Available from: <https://www.thenews.com.pk/print/852739-lahore-water-level-stops-declining-first-time-in-history>, 2021.
- [20] Growing water crisis disastrous for Pakistan's stability, says report Read more At: <https://www.aninews.in/news/world/asia/growing-water-crisis-disastrous-for-pakistans-stability-says-report20210909124218/> [Internet]. ANI. 2021 [cited 9 September 2021]. Available from: <https://www.aninews.in/news/world/asia/growing-water-crisis-disastrous-for-pakistans-stability-says-report20210909124218/>.
- [21] I. Staff Team, Issues in managing water challenges and policy instruments: regional perspectives and case studies [Internet], *IMF* (2015) [cited June 2015]. Available from: <https://www.imf.org/external/pubs/ft/sdn/2015/sdn1511tn.pdf>.
- [22] Pakistan may face severe water shortage, warn experts [Internet]. *The News*, [cited 4 July 2021]. Available from: <https://www.thenews.com.pk/amp/859365-pakistan-may-face-severe-water-shotage-warn-experts>, 2021.

- [23] A. Salman, Pakistan's looming water crisis | East Asia Forum [online], East Asia Forum (2022). Available at: <https://www.eastasiaforum.org/2021/11/13/pakistan-s-looming-water-crisis/>. (Accessed 23 January 2022).
- [24] [www.dw.com](https://www.dw.com/en/how-climate-change-is-aggravating-pakistans-water-crisis/a-41315151) D. How climate change is aggravating Pakistan's water crisis | DW, 09.11, [Internet]. DW.COM. 2022 [cited 23 January 2022]. Available from: <https://www.dw.com/en/how-climate-change-is-aggravating-pakistans-water-crisis/a-41315151>, 2017.
- [25] Pakistan council of research in water resources (PCRWR). Water scarcity in Pakistan issues and options. Hilal, Available from: <http://pcrwr.gov.pk/wp-content/uploads/2021/07/Water-Scarcity-in-Pakistan-Issues-and-Options-May-18.pdf>, 2018, 34-38.
- [26] Pakistan population 2022 (demographics, maps, graphs) [Internet]. Worldpopulationreview.com, [cited 23 February 2022]. Available from: <https://worldpopulationreview.com/countries/pakistan-population>, 2022.
- [27] Water scarcity crisis in Pakistan: causes, effects, solutions [Internet]. Envypk.com - Latest Environmental News and Research from Pakistan!, [cited 23 February 2022]. Available from: <https://www.envypk.com/water-scarcity-crisis-in-pakistan-causes-effects-solutions/>, 2022.
- [28] SDG 6 - ensure access to water and sanitation for all [Internet]. Millennium Development Goals, [cited 13 February 2022]. Available from: <https://www.mdgmonitor.org/sdg6-ensure-access-to-water-and-sanitation-for-all/>, 2022.
- [29] [Internet]. 2022 [cited 13 February 2022]. Available from: <https://www.reuters.com/article/us-pakistan-drought-malnutrition-idUSKCN1QI40Esitara-e-shujaat-nishan-e-imitiaz>.
- [30] Thar — the future of Pakistan [Internet]. Thenews.com.pk, [cited 13 February 2022]. Available from: <https://www.thenews.com.pk/print/307505-thar-the-future-of-pakistan-by-senator-rehman-malik>, 2022.
- [31] M. Raza, Thirsty days ahead: Pakistan's looming water crisis [Internet]. Thediplomat.com, [cited 24 February 2022]. Available from: <https://thediplomat.com/2018/06/thirsty-days-ahead-pakistans-looming-water-crisis/>, 2018.
- [32] 1 in 3 people globally do not have access to safe drinking water – UNICEF, WHO [Internet]. Who.int, [cited 13 February 2022]. Available from: <https://www.who.int/news/item/18-06-2019-1-in-3-people-globally-do-not-have-access-to-safe-drinking-water-unicef-who>, 2022.
- [33] The first line of defence [Internet]. Thenews.com.pk, [cited 13 February 2022]. Available from: <https://www.thenews.com.pk/print/729428-the-first-line-of-defence>, 2022.
- [34] F. Newspaper, Contaminated water [Internet]. DAWN.COM, [cited 29 January 2022]. Available from: <https://www.dawn.com/news/1657638/contaminated-water>, 2022.
- [35] Effects of the water crisis on health | Water.org [Internet]. Water.org, [cited 29 January 2022]. Available from: <https://water.org/our-impact/water-crisis/health-crisis/>, 2022.
- [36] 53,000 children die of diarrhoea caused by contaminated water every year [Internet]. DAWN.COM, [cited 13 February 2022]. Available from: <https://www.dawn.com/news/1381735/53000-children-die-of-diarrhoea-caused-by-contaminated-water-every-year>, 2022.
- [37] Arsenic in drinking water threatens up to 60 million in Pakistan [Internet]. Science.org, [cited 29 January 2022]. Available from: <https://www.science.org/content/article/arsenic-drinking-water-threatens-60-million-pakistan>, 2022.
- [38] R. Blyth, Three stars for every student — the evolution of wash in schools [Internet]. Centre for Affordable Water and Sanitation Technology (CAWST), [cited 1 March 2022]. Available from: <https://www.cawst.org/blog/three-stars-for-every-student-evolution-of-WASH-in-schools>, 2021.
- [39] B. Desye, COVID-19 pandemic and water, sanitation, and hygiene: impacts, challenges, and mitigation strategies, *Environ. Health Insights* 15 (2021 Jul), 11786302211029447.
- [40] S. Baloch, Water crisis: why is Pakistan running dry? | DW | 07.06 [Internet]. DW.COM. 2022 [cited 23 February 2022]. Available from: <https://www.dw.com/en/water-crisis-why-is-pakistan-running-dry/a-44110280>, 2018.
- [41] M. Soomro, Not a drop [Internet]. Thenews.com.pk, [cited 23 February 2022]. Available from: <https://www.thenews.com.pk/print/908765-not-a-drop>, 2021.
- [42] C. Sadoff, M. Smith, Water in the COVID-19 crisis: response, recovery, and resilience - World [Internet]. ReliefWeb, [cited 23 February 2022]. Available from: <https://reliefweb.int/report/world/water-covid-19-crisis-response-recovery-and-resilience>, 2020.
- [43] Is Pakistan's water crisis a natural calamity or man-made? [Internet]. WwF, [cited 23 February 2022]. Available from: https://www.wwfpak.org/knowledge_hub/_natura/_natura_volume_4_issue_2_2020/is_pakistan_s_water_crisis_a_natural_calamity_or_man_made/, 2020.
- [44] H. Ni'Shuilleabhain, In Pakistan, pandemic derails water, sanitation, and hygiene work [Internet]. Circle of Blue (2020) [cited 13 February 2022]. Available from: <https://www.circleofblue.org/2020/world/in-pakistan-pandemic-derails-water-sanitation-and-hygiene-work/>.
- [45] F. Ahmed, M. Shahid, Y. Cao, M. Gohar Qureshi, S. Zia, S. Fatima, et al., A qualitative exploration in causes of water insecurity experiences, and gender and nutritional consequences in South-Punjab, Pakistan [Internet]. PubMed, [cited 13 February 2022]. Available from: <https://pubmed.ncbi.nlm.nih.gov/34886260/>, 2021.
- [46] R. Watts, D. Walton, T. Yeung, N. Ahmad, N. Mubashar, R. Panhwar, et al., Equal to the task: financing water supply, sanitation and hygiene for a clean, green and healthy Pakistan, Water Aid (2020) [Internet], https://washmatters.wateraid.org/sites/g/files/jkxooof256/files/equal-to-the-task-financing-water-supply-sanitation-and-hygiene-for-a-clean-green-and-healthy-pakistan_2.pdf [cited 13 February 2022]. Available from:
- [47] I. Saqib Khalid, Managing risks to water and sanitation amid COVID-19: policy options for Pakistan, JSTOR (2020) [Internet], https://www.jstor.org/stable/resrep24356?seq=4#metadata_info_tab_contents [cited 13 February 2022]. Available from:
- [48] S. Meer Baloch, Water crisis: why is Pakistan running dry? [Internet]. DW, [cited 13 February 2022]. Available from: <https://www.dw.com/en/water-crisis-why-is-pakistan-running-dry/a-44110280>, 2018.
- [49] Water crisis looms large in Pakistan, may face absolute scarcity by 2040 [Internet], Business Standard (2021) [cited 13 February 2022]. Available from: https://wap.business-standard.com/article-international/water-crisis-looms-large-in-pakistan-may-face-absolute-scarcity-by-2040-121032200050_1.html.
- [50] A. Khan, Water conservation campaign [Internet]. Thenews.com.pk, [cited 24 February 2022]. Available from: <https://www.thenews.com.pk/print/401063-water-conservation-campaign>, 2018.
- [51] S. Jamal, Pakistan begins construction of diamer Bhasha dam [Internet]. Gulfnews.com, [cited 24 February 2022]. Available from: <https://gulfnews.com/world/asia/pakistan/pakistan-begins-construction-of-diamer-bhasha-dam-1.72607867>, 2020.
- [52] A. Amir, Obstacles remain for Pakistan dam backed by China [Internet]. Lowyinstitute.org, [cited 24 February 2022]. Available from: <https://www.lowyinstitute.org/the-interpreter/obstacles-remain-pakistan-dam-backed-china>, 2020.
- [53] Rainwater harvesting project Lahore - why we need more? [Internet]. Envypk.com - Latest Environmental News and Research from Pakistan!, [cited 24 February 2022]. Available from: <https://www.envypk.com/rainwater-harvesting-project-lahore-why-we-need-more/>, 2021.
- [54] Dire need of sea water desalination plants in Baluchistan Pakistan [Internet]. Envypk.com - Latest Environmental News and Research from Pakistan!, [cited 24 February 2022]. Available from: <https://www.envypk.com/dire-need-of-sea-water-desalination-plants-in-baluchistan-pakistan/>, 2021.
- [55] S.L. Young, et al., Perspective: the Importance of Water Security for Ensuring Food Security, Good Nutrition, and Well-Being, vol. 12, 2021, pp. 1058–1073, 4.
- [56] S. Deng, et al., The utilization of reclaimed water: possible risks arising from waterborne contaminants, *Environ. Pollut.* 254 (Pt A) (2019), 113020.
- [57] M. Achore, et al., Coping with water insecurity at the household level: a synthesis of qualitative evidence, *Int. J. Hyg Environ. Health* 230 (2020), 113598.
- [58] N. Koyraty, et al., Food Insecurity and Water Insecurity in Rural Zimbabwe: Development of Multidimensional Household Measures, vol. 18, 2021, 11.
- [59] C. Mooney, Over half the world's population suffers from 'severe' water scarcity, scientists say [Internet], Wash. Post (2016) [cited 1 March 2022]. Available from: <https://www.washingtonpost.com/news/energy-environment/wp/2016/02/12/the-world-has-even-bigger-water-problems-than-we-thought/>.

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